



THE ANDERSON & FELIX



***GUIDE TO NAVAL ARCHITECTURE
3RD EDITION***



THE ANDERSON AND FELIX GUIDE TO NAVAL ARCHITECTURE

Author

Michael Johnson

Artists

Ian Stead (Cover, p.15,19,24,25,32,33,36,53,63,66,67,72-74,80,87,88,91,115,119,120,122,125,126,129,135,138,140,143,144,146,147,154,165,166,172,174,176,189,193,196,199,206,207,210,213,216,219,222,226,227,241); Bradley Warnes (p.20,22,50,52,57,68,94,96,101,107,108,114,155,179,205,231,238) Michael Johnson (p.228,229,230,232,234-236,239,240); Sam Harvey (p.159,161-164); Crom (p.148)

Cover Layout Design, Anderson & Felix Logo, and Clement Sector Logo
Stephanie McAlea

Cover Template

George W. Krubski

Editor

Curtis Rickman

Playtesters

Timothy Howe, John Watts, Wendy Watts, Mike Nixon, George Minter, Graham Bonny, James Willoughby, Nick Cook, Anthony Faulkner, and Alan Mullican

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Introduction

Ranging from tiny ten-tonne work pods to massive armored system defense monitors, the spaceships of Clement Sector are as varied as the crews that operate them.

This book provides the tools for a naval architect to design small craft to huge in-system ships, traders, or capital ships. They can install the latest technology to allow the ship to transit interstellar distances, use inertialess drives or to “ride fire” on a ship that uses spin gravity to provide for crew comfort. They can also design low technology missile armed warships or capital ships bristling with high energy weapons and ship killing torpedoes.

Clement Sector is essentially a TL 12 small ship setting. The Zimm Drive, a quantum entanglement device allowing FTL travel, limits starships to an absolute maximum of 5000 tonnes and it is extremely rare to find in-system vessels displacing more than 20,000 tonnes.

Computer technology is often higher than the accepted TL 12 “norm” and some ships systems allow for TL 13 technology to be added.

The Anderson and Felix Guide to Naval Architecture will sometimes reference the Clement Sector setting book and other Independence Games’ products. We believe that a Referee will find those books helpful as well.

There are seven modules making up the organizational framework of the Anderson and Felix Guide to Naval Architecture. These modules are listed below.

Module 1	Spacecraft Design
Module 2	Small Craft Design
Module 3	Reaction Drives
Module 4	Zimm Drive Alternatives
Module 5	Advanced Space Combat
Module 6	Spacecraft of Clement Sector
Module 7	A Primer on Creating Deck Plans

Both adventure class ship and capital ships can be designed using this publication.

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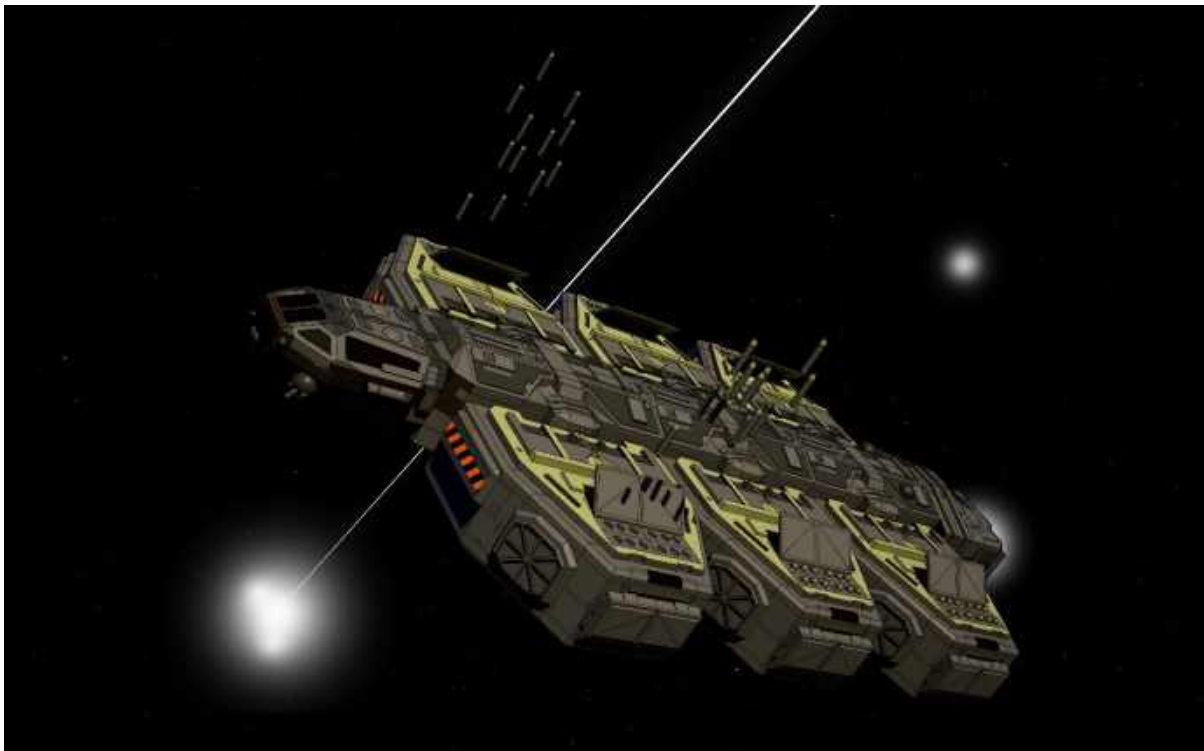
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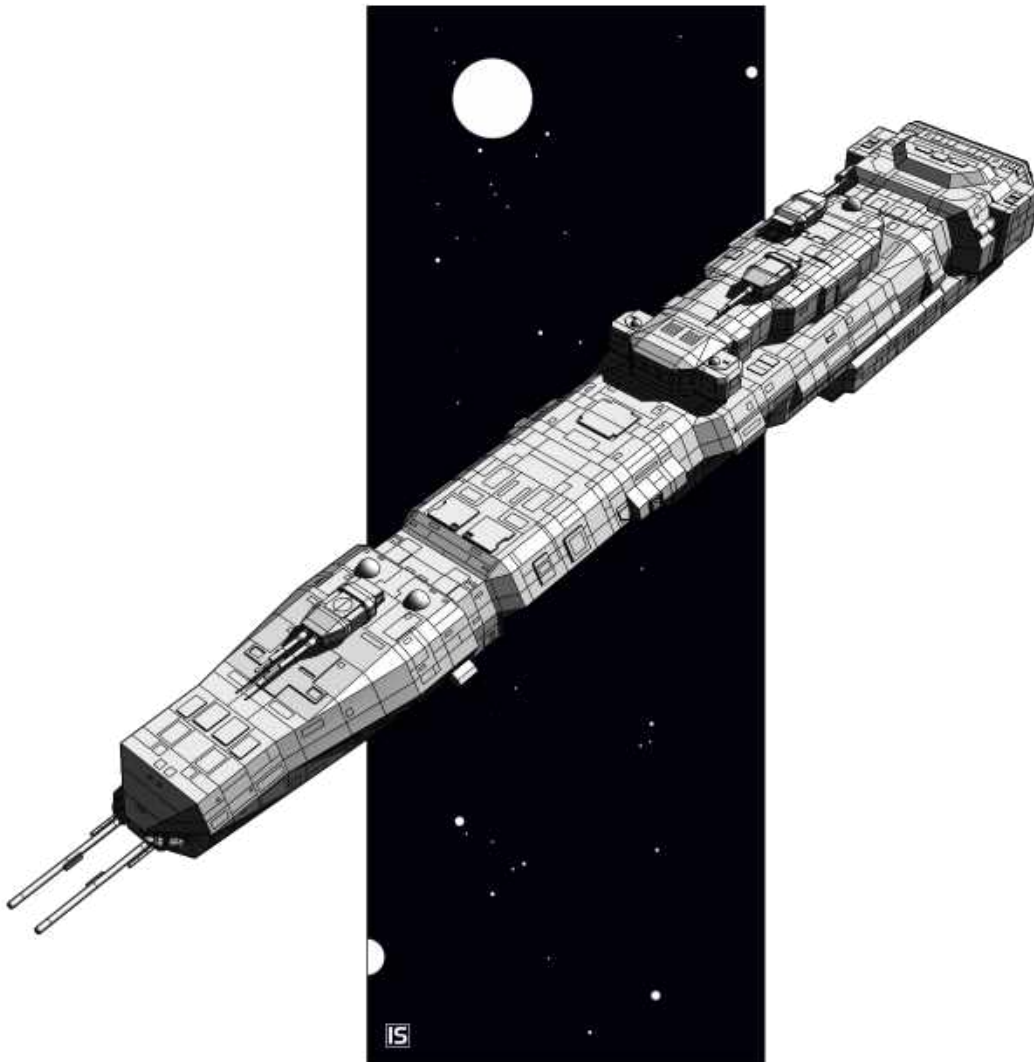


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Anderson and Felix Shipbuilders Company

Currently the largest ship building company in Clement Sector, the Anderson and Felix Shipbuilders Company was started on Hub in 2299 by Jamie Anderson and Reynaldo Felix. Both Anderson and Felix brought to Clement Sector their considerable expertise and experience constructing space vessels for travel between Earth and the Earth Sector colonies.

Expanding from what is now their corporate headquarters in Vogel and currently operating two shipyards within the Hub Federation; A&F can design and construct vessels from small craft to giant in-system transports.

Their current main shipyard is in orbit around Hub and this massive shipyard, able to construct any size vessel, has become the main shipyard in the subsector. The second A&F shipyard in orbit around Wilhelmveldt has become the second busiest shipyard in the subsector.

The majority of ships seen in the Hub subsector at present have been built at one of these two shipyards. All the Hub Federation Navy ships, which were not part of the pre-Collapse national fleets, are built at Anderson and Felix. These include the Hub Federation Navy *Kiviat* -class corvettes, the *Moltke*-class cruisers, and the *Vulkan*-class assault boat tenders - which were designed and constructed at the Wilhelmveldt shipyard. Many corporations, such as Blaylock Mining, the Blue Star Line, and Winterkorp have their ships built at these yards as well.



"Anderson and Felix Shipbuilders, in cooperation with the Hub Federation Navy and The Combined Council of Academic Learning have made this spaceship design primer available for all first year, first semester naval architects throughout the Hub Federation.

I hope that it will be of great benefit and assist all those beginning their academic training in their chosen career." - Dr. Eric Bodley, Director of Design and Development, A&F Wilhelmveldt 2340 (standard)

Authors Note

This updated third edition of Anderson and Felix Guide to Naval Architecture has been written for use within the Clement Sector setting. Clement Sector is a small ship setting, with restrictions on the size of starships bought about by the Zimm drive, the setting's only means of FTL interstellar travel. Further, Clement Sector has an overall maximum technological level of 12 though some technology, notably computers are higher.

Even with these restrictions, the Anderson and Felix Guide to Naval Architecture can be used in any setting with the referee or designer simply substituting back elements of those settings requirements or for that matter, any type of alternative setting-based guidelines wished. There is plenty of information in A&F to interest any referee or designer, including the pre-gravitic module, which allows for more detailed designs. I do hope you enjoy the book.

Module 1 - Spacecraft Design

The Design Process

Spacecraft are constructed on the foundation of a hull, into which are fitted the Zimm and maneuver drives, the power plant, the fuel tanks, accommodation for the crew, computers, controls, and sensors.

Optionally, other components such as armaments, defensive systems, and other fittings can be added to adapt the ship to its intended function. The total tonnage of the installed fittings cannot exceed the tonnage of the hull.

Before commencing design, determine the role intended for the ship and any associated specialization that role might require.

1. The Hull

- a. Choose Hull size and configuration.
- b. Install armor and any hull options.

2. The Engineering Section

- a. Choose drives and power plant. If designing a reaction drive vessel then refer to module 2 for drive type selection.
 - i. Decide what the maximum acceleration for the ship should be, and cross-reference it with the ship's tonnage on the Performance by Hull Volume Table to determine the Maneuver Drive required.
 - ii. Optionally, select a Zimm Drive by cross-referencing it with the ship's tonnage on the Zimm Drive Letter Table to determine the Zimm Drive required. The result can then be cross-referenced with the Drive Costs Table.
 - iii. Choose a Power Plant, ensuring that it can provide enough power for the Zimm and Maneuver Drives.
 - iv. For reaction drive vessels, determine spin gravity requirements and allocate space for that type.
- b. Fuel
 - i. Calculate fuel requirements and allocate space for fuel (reaction drive vessels also require reaction mass).

3. The Main Compartment

- a. Install a bridge.
- b. Install a computer.
 - i. Install computer software. If a Zimm Drive has been installed, then the ship needs Zimm Drive software.
- c. Install sensors.
- d. Install internal components such as staterooms, berths, low berths, medical bays, workshops, or recreation facilities.
- e. Install external components such as aerofins, docking clamps, grapppling arms

4. Armament

- a. Install Point Defense Node Array if required.
- b. Determine hard points and if required, install any turrets, barbettes, or bays.
 - i. Optionally install spinal weapon if ship is a large enough in-system capital ship.
 - ii. Ensure one tonne of fire control per turret, barbette, or bay.
- c. Install weapons.
- d. Missile launchers, mine launchers, torpedo launchers, mass drivers, railguns and sandcasters require ammunition and magazine space must be allocated.
- e. Install screens if required.

5. Small Craft, Vehicles, Drones and Cargo Holds

- a. Install drones if required.
- b. Determine hangar requirement for vehicles and small craft if required.
- c. Allocate cargo space and cargo hold type.

6. Crew

- a. Determine crew required to operate the ship effectively and adjust the allocated accommodation if necessary.
- b. Passengers.

Note that any remaining space can be added or removed from allocated cargo space to ensure the design balances and does not exceed the selected hull displacement.

For capital ship section hit tables and crew strength characteristics, refer to page 110 and page 111.



Spacecraft are constructed and sold at shipyards throughout Clement Sector. Any A-class starport has a shipyard, which can build any kind of ship, including a starship with Zimm drives; any B-class starport can build small craft and ships, which do not have Zimm drives. The military procures spaceships through these yards, corporations buy their commercial craft from these shipyards, and private individuals can purchase ships that they have designed through them as well. The major restriction on the purchase of ships is money.

Definitions

A spacecraft is defined as an interplanetary or interstellar vehicle, which can travel through space under its own power.

Spacecraft are further defined by the criteria that a ship is any vessel of one hundred tonnes or more. A starship has a Zimm Drive and can travel on interstellar voyages from star system to star system and an in-system ship (which navies often call a boat or, if very large, a monitor) which has no Zimm Drive and is thus confined to a single star system.

Small craft are any vessel under one hundred tonnes and are incapable of being able to form a stable Zimm Bubble. For small craft design, see module 2. Data for the more common types used throughout Clement Sector can be found in Independence Games' *Ships of Clement Sector 4-6: Traders, Scouts, and Small Craft*.

Size is measured in 'displacement tonnes' or dT: a hundred-tonne ship displaces a volume equal to one hundred tons of liquid hydrogen (one dT equals roughly 14 cubic meters). Tonnes or dT in this supplement are interchangeable.

Standard Designs vs. New Designs

There are many ship designs used within Clement Sector that can be purchased "off the shelf" or used as a basis for custom modifications. Plans for such spacecraft are available in most shipyards and components are standardized across all the shipyards that can construct that vessel, which will reduce the cost of the ship's construction by 10%. This reduced cost does not include ammunition for weapons or fuel, which must be bought separately. If a buyer needs a new, custom type of ship, then they must employ a ship architect to design it, which will take about two months per 100dT of hull size. An architect typically charges a flat fee of 1% of the final cost of the ship.

Construction Times

It is often difficult to determine construction times as they can vary wildly. Times are dependent on size, complexity of the spacecraft and the construction capabilities of the shipyard. For the purposes of determining how long a spaceship will take to construct, an assumption can be made that it takes one day per million credits to build a spacecraft at a small commercial shipyard. Larger shipyards such as those owned by Anderson and Felix or Cascadia Orbital will be able to construct ships more quickly. See the Construction Time section on page 112 for indicative times.

Non-Capital Ships (Adventure Class Ships)

Spacecraft that fall within the hull ranges of 100 – 2000 tonnes are traditionally known as Adventure Class Ships. Larger spacecraft, which are far more costly to maintain and operate, tend to be used by system defense forces, navies, or large mercantile and shipping corporations. Smaller warships such as frigates and destroyers fall into this category as well.

In this book Non-Capital (Adventure Class) vessels under 2000 tonnes will be referred to as Non-Capital Ships for ease of description.

Commercial Class and Capital Ships

Nonmilitary vessels over 2000 tonnes are collectively referred to as Commercial Class Ships. Military vessels are known as Capital Ships. However, for design purposes both use the same design guidelines. To confuse the issue further, navies also classify larger warships such as battleships and carriers as Capital Ships.

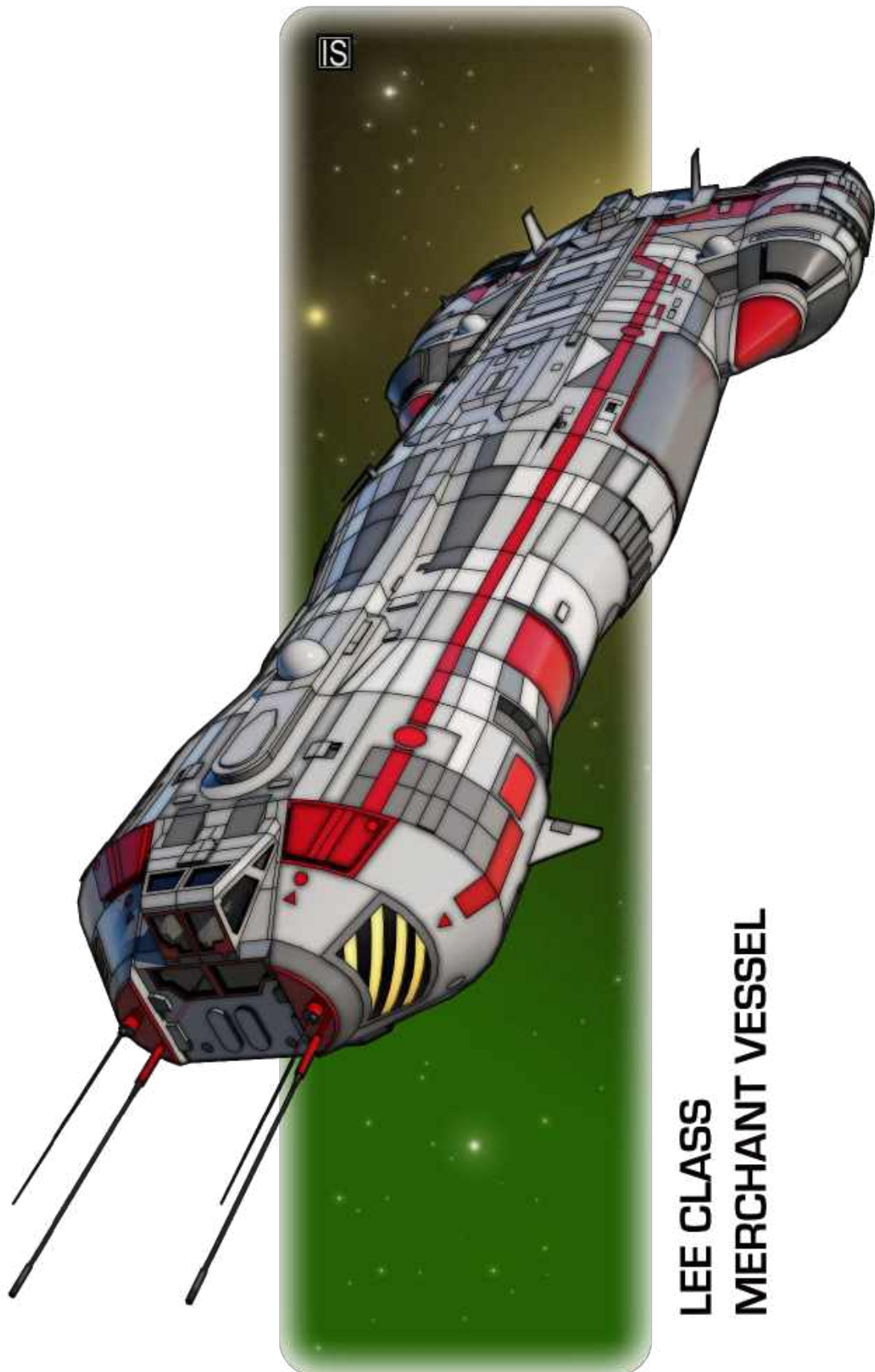
Naval Capital Ships have differing design criteria to Commercial Class vessels of similar displacement. Drives for example, tend to be larger and more robust allowing for greater thrust and providing more power output for offensive and defensive armament and combat maneuvering. Naval Capital Ships prioritize protection and armament whilst Commercial Class will be designed to maximize cargo carrying capacity.

In this book Commercial class and Capital Ship vessels over 2000 tonnes will be referred to as Capital Ships for ease of description.



Design example

Having received a design order for a small merchant vessel from a client, the naval architect determines that a 200 tonne (dT) hull would be a suitable choice. This would allow enough room for an economical drive selection, crew, passengers and good cargo capacity for the ship's displacement.



1. The Hull

Hulls are identified by their displacement, expressed in tonnes (dT).

Due to the way the Zimm Drive works, a vessel that contains a Zimm Drive cannot ever be over 5000 tonnes displacement. Most starships will stay well below that upper limit, though some of the bigger national navy capital ships in Earth Sector get close. For more information on the Zimm Bubble limit, refer to the section on Starship Operations in the Clement Sector Core Setting book.

Vessels not required to undertake interstellar travel with a Zimm Drive will not face this size limitation. Therefore, in-system ships can be built with any size hull up to 20,000 tonnes.

Ships that fall within the hull ranges of 100 – 2000 tonnes are traditionally known as Adventure Class Ships (Non-Capital ships), while larger ships, which are far more costly to maintain and operate, tend to either be used by system defense forces, navies, or large corporations.

For navies, the accepted hull range for Capital Ships falls between 2,001 and 20,000 tonnes and are designated by the appropriate Hull Code. A Hull Code includes all hull values between it and the next lowest hull code (so a 12,000dT monitor will have a Hull Code of CJ).

Hull Cost							
Hull (dT)	Hull Code	Price (MCr)					
100	1	2	Non Capital Ships (Adventure Class)	Non Starships	Starships		
200	2	8					
300	3	12					
400	4	16					
500	5	32					
600	6	48					
700	7	64					
800	8	80					
900	9	90					
1000	A	100					
1200	C	120	Capital ships				
1400	E	140					
1600	G	160					
1800	J	180					
2000	L	200					
3000	CA	300					
4000	CB	400					
5000	CC	500					
6000	CD	600					
7000	CE	700					
8000	CF	800					
9000	CG	900					
10,000	CH	1000					
15,000	CJ	1500					
20,000	CK	2000					

Depending on tonnage, a capital ship is compartmented in up to three sections. Any attacks on a ship will hit one section or another. During the design process, the section should be named when components are allocated to it. Such allocated components are then used to populate the vessel's section hit table. Refer to page 180 for additional details.

Capital Ship Hull Section Table

Hull Code	Number of Sections	Section 1	Section 2	Section 3
CA to CE	2	Engineering	Forward	
CF to CK	3	Engineering	Main	Forward

Configuration

There are three main types of hull configuration available for a spacecraft.

- Standard (a cone, sphere, or cylinder)
- Streamlined (a needle/wedge, wing, disk or lifting body)
- Distributed (made up of several distinct sub-sections)

If the spacecraft is to be a reaction drive vessel, then there are further hull configuration constraints that affect their performance within planetary atmospheres. See module 3 Reaction Drives for further details.

Standard Hulls

Spacecraft of this hull type can land and leave a planet with an atmosphere but cannot maneuver within that atmosphere. A standard-hull ship can have scoops for gathering fuel from a gas giant, but the process will be much more complex and time consuming. Larger ships with this configuration will use specialized small craft such as a modular cutter to skim gas giants for fuel (See *Clement Sector*, page 449), from orbit or out-system refueling facilities or, if military, refuel from a fleet tanker.

Streamlined Hulls

Spacecraft of this hull type can land, leave, and maneuver in any atmosphere. Streamlining includes fuel scoops, which allow the skimming of unrefined fuel from gas giants or the gathering of water from open lakes or oceans. Streamlining must be included at the time of construction and increases the cost of a hull by 10%.

Distributed Hulls

Ships of this hull type cannot land on any planetary surface or enter any atmosphere type. They are unable to mount fuel scoops. Selecting this hull configuration reduces the cost of the hull by 10%

There are two distributed hull sub-types:

- Close Structure hulls have a closely connected arrangement of sub sections arranged around the main hull. Though it is possible to land a ship with this hull configuration, it is a very risky and time-consuming task to undertake. However, a ship with a close structure can land on planets with thin atmospheres. Selecting this hull configuration reduces the cost of the hull by 10%.
- Dispersed Structure hulls are an open type with hull sections connected by closed or open framework. Selecting this hull configuration reduces the cost of the hull by 50%.

For naval vessels, hull configuration is an important consideration as it affects both the number of weapons than can be bought to bear on a given target and for larger system ships such as monitors, installation of spinal mounts.

Capital Ship Hull Configuration Table

Configuration	Hull Shape	Spinal Weapons	Bearing (%)
Standard		Yes	80
Streamlined	Cone	Yes	70
	Needle/wedge	Yes	80
	Cylinder	Yes	80
Distributed	Cone	Yes	70
	Close Structure	Yes	60
	Dispersed Structure	No	60

For naval vessels, hull configuration is an important consideration as it affects both the number of weapons than can be bought to bear on a given target and for larger system ships such as monitors, installation of spinal mounts.

Hull and Structure

Hull and Structure points are determined by a ship's hull displacement. During combat, any damage suffered by a ship will be reflected by losses to those point values. Initially, damage is applied to the Hull and once the Hull is breached, further damage is applied to the ship's Structure. If all Structure Points are lost, then the ship is considered destroyed. However, the likely outcome is that most spacecraft will surrender, be disabled, or be destroyed by secondary effects before their Structure is eliminated. A ship has one Hull Point and one Structure Point per 50 tonnes of displacement.

A capital ship's internal structure and hull is arranged differently to reduce the damage caused by combat. Each section has its own allocation of Structure and Hull points.

Capital Ship Hull Section Points Table

Tonnes (dT)	Hull Code	Sections	Total		Per Section	
			Hull	Structure	Hull	Structure
3000	CA	2	60	60	30	30
4000	CB	2	80	80	40	40
5000	CC	2	100	100	50	50
6000	CD	2	120	120	60	60
7000	CE	2	140	140	70	70
8000	CF	3	160	160	53	53
9000	CG	3	180	180	60	60
10,000	CH	3	200	200	66	66
15,000	CJ	3	300	300	100	100
20,000	CK	3	400	400	133	133

The following design options alter the basic framework of the ship but will require considerably more time in a shipyard to install.

Reinforced Structure

By reinforcing the structure of a ship and adding armored protection to that, a ship can withstand more damage structurally. For every 5% of the ship's total tonnage allocated to reinforced structure, the ship gains extra structure points. Reinforcing a ship's structure costs 0.2MCr per dT.

Reinforced Hull

Reinforcing the external hull of a ship is cheaper and easier than reinforcing the internal structure. For every 10% of the ship's total tonnage allocated to reinforced hull, the ship gains extra hull points. Reinforcing a ship's hull costs 0.1MCr per dT.

Reinforced Hull

Hull Size	Reinforced Structure per 5%	Reinforced Hull per 10%
10-90	1	3
100-1000	2	5
1001-3000	4	10
3001-20,000	8	20

Armored Bulkheads

Providing additional armor by adding armored bulkheads will provide additional protection to any internal components to which they are added. This will require tonnage equal to 10% of the tonnage of the protected system but will negate the first hit on that system.

For example, if a ship has a 30dT power plant, then adding armored bulkheads to protect the reactor costs 3dT but means the first hit on the power plant is ignored. Adding armored bulkheads to a ship costs 0.2MCr per dT.

Modular Hull

Up to 75% of a ship's internal tonnage may be designated as modular, allowing it to be swapped out easily. This tonnage may not include the bridge, power plant, drives or any structural or armor options. Different modules can be installed for different tasks. Making a modular hull increases the cost of the overall hull by the percentage designated to be modular.

Example: A 100dT hull normally costs 2.0MCr. If 30% of the ship's hull is going to be made modular, then the cost of the hull is increased to 2.6MCr, which is 130% of the original cost. This means that 30dT of the ship's components could easily be swapped out from mission to mission. When hauling passengers, the ship could install a module with six staterooms and 6dT of cargo space (totaling 30dT). When going into combat, the ship could install a module with a triple turret and a fighter hangar totaling 30dT.

Armor

The basic hull provides some protection from anti-ship weapons fire, but it is possible to add heavier armor to the hull for added defense. Naval vessels will always add armor, the amount depending on the role and size of the vessel.

The amount of armor that can be added to a spacecraft is determined by the technological level of the type of armor added. This is defined by the table below.

Armor Type	TL	Protection	Cost	Maximum Armor
Titanium Steel	7	2 per 5%	5% of base hull	TL or 9 whichever is less
Crystaliron	10	4 per 5%	20% of base hull	TL or 12, whichever is less

There is no requirement to add armor in 5% elements, but it must be added in whole armor point values.

For example, the minimum element which can be added for Titanium Steel is 2.5%, which is a single point of armor.

Any selected armor options must be added during the installation of the ship's armor and cannot be easily retrofitted without considerable time in a shipyard.

Hull Options

Heat Shielding

Heat shielding protects the ship against the heat of re-entry or other heat sources such as proximity to a star. A ship without a functioning gravitic drive attempting re-entry without heat shielding or atmospheric thrusters will burn up during the attempt. If equipped with undamaged heat shielding, re-entry is successful on easy (+4) Pilot, 10 - 60 minutes skill check, with failure resulting in burn up (this task is often undertaken more slowly). Damage to the ship from proximity to a star in the absence of heat shielding will be severe. Heat shielding does not provide protection against starship combat weapons, even fusion weapons. Heat shielding costs 0.1 MCr per dT of hull.

Radiation Shielding

Radiation shielding improves the ship's protection so that it is shielded against artificial radiation sources (such as nuclear missile detonations and meson gun impacts) and against radiation from natural sources (such as solar flares, system bodies and pulsars). A ship with radiation shielding decreases the amount of rads absorbed by all crew by 1000, treats the bridge as if it is hardened and provides 6 extra armor points against radiation damage from nuclear weapons, particle beams and fusion guns. For more powerful meson gun weaponry, the provided protection reduces to 4 extra armor points. Radiation shielding costs 0.1MCr per dT of hull. Due to its high-cost radiation shielding tends to only be installed on warships. However, it cannot be installed alongside a Magnetogravitic (MaGG) shield (see page 87).

Self-Sealing

A self-sealing hull automatically repairs minor breaches such as micrometeoroid impacts and prevents hull hits from leading to explosive decompression. It costs 0.01MCr per dT of hull. All military vessel hulls are automatically considered self-sealing.

Electrified

An electrified hull is a defensive system that charges the hull with high voltage current directly tapped from the ships power plant. The inside of the vessel is insulated. Designed to discourage dangerous life forms and intruders attempting to gain access to the vessel, the charge level can be varied from 1- 6d6 damage. Referees may judge that armor and some suits can reduce or nullify this damage. It costs 0.2MCr per dT of hull, requires a working power plant to function and has no benefit or effect in space combat.

Reflec

Reflective coating on the hull increases the ship's armor against lasers by 3. Adding Reflec costs 0.1MCr per dT of hull and can only be added once.

Stealth

A stealth coating absorbs radar and lidar beams and disguises heat emissions. This gives a -4 DM on any Sensors rolls to detect or lock onto the ship. Adding Stealth costs 0.1MCr per dT of hull and can only be added once.

Hull Option Summary

Hull Option	TL	Cost (MCr) per Hull Tonnes
Heat Shielding	7	0.1
Radiation Shielding	8	0.25
Self-Sealing	9	0.1
Electrified	9	0.2
Reflec	10	0.1
Stealth	11	0.1

Displacement Tons to Mass Tons Conversion

It is often useful to have a sense of what the displacement tonnage of a space vessel is in mass tons. The table below provides a multiplier for such a calculation.

This conversion process provides an approximation of the true mass tonnage of the vessel with such items such as the mass of hull armor, bulky internal components, weapons, and any small craft carried reflected by the multiplier value.

Displacement Tons to Mass Tons Conversion

Ship Type	Example	Multiplier
Civilian Ships & Small Craft	Adventure Class & Commercial Class ships	x5
Lightly Armored Warship	Frigates, Sloops, Destroyers, Carriers	x6
Moderately Armored Warship	Cruisers, Battlecruisers	x7
Heavily Armored Warship	SBD's, Battleships, Monitors	x8

For example, the mass tonnage of a 3000 displacement tonne heavy cruiser will be 21,000 mass tonnes (3000 x 7) while a ubiquitous 300 displacement ton Rucker-class merchant vessel would be 1500 mass tons (300 x 5).

Design example – The Hull

Deciding on a 200dT hull, the designer adds streamlining as the trader is required to be able to enter atmosphere. This adds 10% to the hull cost. They then add 4 points of crystaliron armour to further protect the ship if an antagonist decides to attack with missiles and lasers rather than words.

Hull Cost table = Hull Code 2, 200dT costs 8MCr.

Streamlined configuration = 10% x hull cost = 0.8MCr.

Hull Points = 1 point per 50dT hull = 200/50 = 4

Structure Points = 1 point per 50dT hull = 200/50 = 4

Armour = Crystaliron 5% x hull tonnage at 20% x hull cost = 10dT for 1.6MCr.

Hull summary: Allocation = 10dT, Cost = 10.4MCr.

2. The Engineering Section

Hulls vary in their requirements for drives and power plants based on tonnage and any specific drive will be less efficient as the tonnage it must create thrust for increases. The drive potential table on page 39 lists 24 standard maneuver drives and power plant types, identified by the letters A through Z (omitting I and O to avoid confusion). Also listed are various standard hull tonnages. If any odd sized, custom hull tonnages are required then those should be read at the next higher hull tonnage level. Correlating hull size with drive letter indicates drive potential. If a hyphen (-) is listed, then that combination of drive and hull is not allowable.

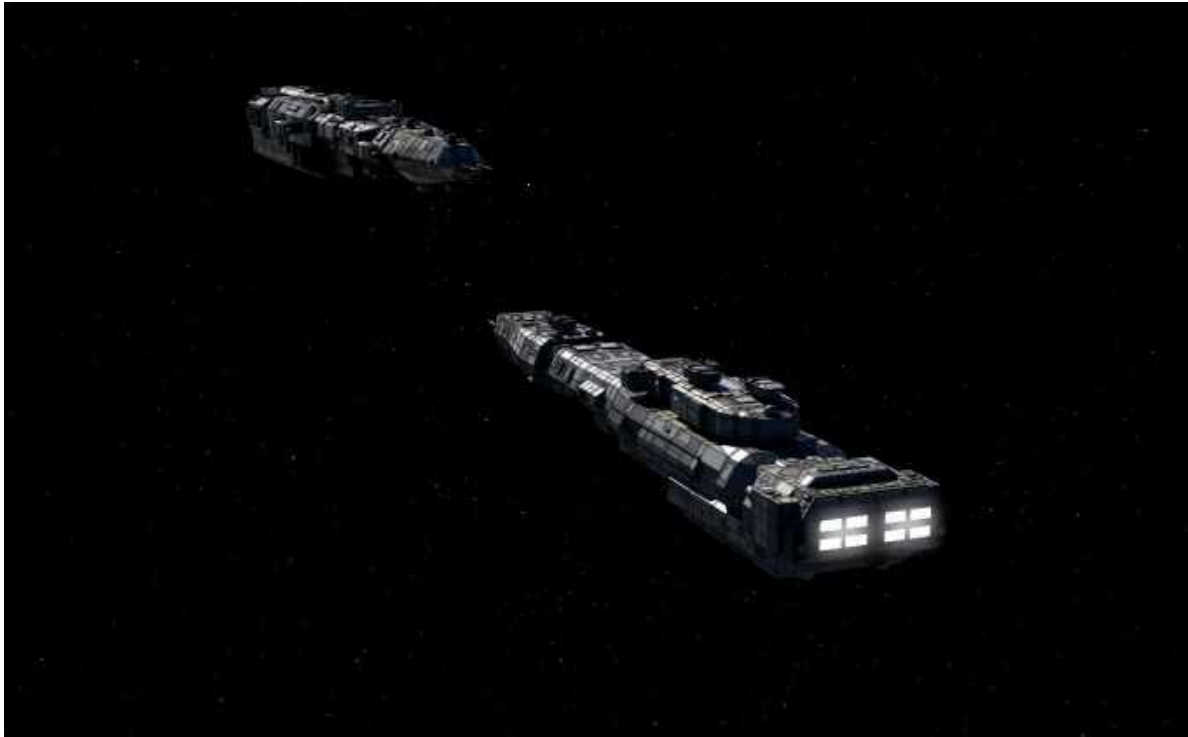
For maneuver drives, the potential is the Thrust, which is the maximum number of G's acceleration available for that drive type.

Zimm Drives are selected from the Zimm Drive table on page 38.

For any spacecraft with a Zimm drive then the power plant rating (A-Z) must be at least a rating of 2.

For example, if a 500dT ship outfitted with a Zimm Drive G and a maneuver Drive N would have a Thrust of 5. As the Zimm Drive is rated at 2, it would thus require a power plant N to operate, equal to the higher rating of the two drives.

Civilian ships and smaller naval vessels use "off the shelf" drive components. These provide enough power and thrust for the task. Bigger Naval capital class vessels on the other hand are more heavily armed, armored, and full of redundant systems and require more powerful purpose-built drives to provide everything needed with power and to be able to maneuver in combat. Commercial class vessels, though not designed for combat, still require larger drives to be able to operate.



Maneuver Drive

The gravitic drive is the standard for spacecraft throughout human colonized space. First theorized in 2174, the first practical application of the theory was developed by the Chinese in 2231. The gravitic drive combines efficiency with moderately high thrust, requiring only the power generated by a power plant to function. Two other drives are also used as a lower technology option.

- Reaction drives or rockets can provide greater thrust but require prohibitively large amounts of reaction mass.
- Solar sails, by contrast, require no power or reaction mass, but generate extremely low thrust preventing its use for anything other than solar sail enthusiasts.

Reaction Drive

A reaction drive operates by simply ejecting matter rearwards of the spaceship at high velocity. Different types of drives do this in different ways, but all require on-board supplies of reaction mass to be used to propel the spacecraft. See module 3 on page 148 for reaction drive design options.

Solar Sail

A deployed solar sail covers an area dozens of kilometers across. It is made of a flexible synthetic fabric that has limited self-repair capabilities. Particles emitted by the sun (the 'solar wind') catch the sail and provide a minuscule amount of thrust. A ship using a solar sail as its primary method of propulsion has an effective thrust of 0 and requires several days or weeks to change its course or speed.

A solar sail costs 0.01Mcr per dT of ship and takes up 5% of the ship's total tonnage when stowed. It cannot be used during combat or when a Zimm Drive is engaged.

A Note on Maneuvering Thrusters

Considered part of the M-drive tonnage allocation these thrusters provide 0G Maneuvering Thrust only, essential for station keeping and docking operations. Chemical reactant based at TL8 and TL9 and plasma at TL 10 and higher, thrusters are concentrated around the bow and stern with thruster nodes spaced around hull for maximum efficiency. They consume negligible tonnage and cost and are not considered part of the overall cost of the vessel.

Artificial Gravity and Inertial Compensators

The standard normal space drive used throughout human colonized space, the gravitic drive also generates internal gravity for the spacecraft and provides inertial compensation for acceleration up to two gravities higher than the thrust rating of the drive.

A spacecraft's internal gravity is provided by a network of gravity nodes installed under each deck, which generate gravity towards the nodes (and the deck). Internal gravity for each node can be varied from 0G to 3G if required.

For spacecraft constructed without a gravitic drive, a gravitic (AGIC) generator can be installed to provide for internal gravity and inertial compensation. This provides as above but requires internal space and additional cost to install. The AGIC generator is first available at TL9.

An AGIC Generator requires 0.02% of the hull tonnage at a cost of 5MCr per ton. For small craft, an AGIC Generator requires 0.01% of the hull tonnage at a cost of 3MCr per ton.

Power Plants

The standard power plant for spacecraft is the fusion reactor. Compact, efficient, and powerful, it will provide more than adequate power for all ship's systems.

Variable Output

All spaceship drives are capable of variable output to extend the length of the designed operational duration of the vessel. Reducing or "dialing back" power plant output reduces the fuel expenditure but also reduces the number of ship systems on operational readiness or standby. A power plant output may be reduced to provide a vessel with a maximum of five extra operational days while still allowing enough power for life support, basic controls, and a thrust capability of 1G.

Each 10% of power plant reduction increases duration by one day, but at the cost of powering one ship system such as turret power, maneuver drive thrust power, Zimm Drive, sensors etc.

For example, the captain of a free trader who is low on fuel and with a damaged Zimm Drive dials back the power plant output by twenty percent to conserve what fuel is remaining as she heads in-system. She elects to drop the maneuver drive thrust to 1G heading in-system and shuts power down to the two weapon turrets. This gives her the extra two days needed for the journey.

Emergency Power

The ability for a vessel to keep functioning after main power has been disabled or knocked offline can be provided by an emergency power system. Such a system offers a more inexpensive option than installing a second backup power plant. In combat, if the power plant is hit for a third time, the emergency power system activates, and allows the ship to function normally for 30 minutes (5 Combat Rounds), providing full ship wide operations. If the power plant is hit again, then the emergency system will fail. An emergency power system requires an allocation of 10% of the power plant and costs 10% of the cost of the main power plant.

Chemical Power Plants

Much larger and much less fuel efficient than a fusion or fission power plant, the chemical power plant is 40% bigger than its fusion equivalent, costs 1.25MCr per tonne and requires 15 times the amount of fuel for the same period of operation.

Fission Power Plants

Fission plants first become available at TL7, provide the same power as a fusion power plant, and can provide any power performance level. They are however twice the size and price of a fusion power plant of the same rating. Fuel usage is the same as fusion power plants.

Solar Panel

Designed to allow a vessel to extend range and endurance, extendible solar panels provide backup power for a vessel's power plants. If the ship is engaged in minimal maneuvering only, then the ship will consume power plant fuel at 25% of the main power plants fuel consumption rate. If the ship remains on station, does not use active sensors, or engages in fuel refining then no power plant fuel will be used. If solar panels are fitted to a ship as the main power plant, then assume the solar panels provide a performance rating of 1. A ship cannot make a Zimm transition when the panels are deployed.

Solar Panels required to power a ship are 10% the size of the main power plant but cannot be less than 0.5dT. Cost is 0.1MCr per dT.

Chemical Batteries

A chemical battery the same size as a fusion power plant of the same tech level provides a performance rating of 1 and 1000 hours of use. This is assuming the vessel is not maneuvering, using active sensors, refining fuel, making significant use of long-range communicators or energy using weapons (such as lasers, rail guns, meson guns, fusion guns and particle beams). Alternatively, the same sized battery will give 1 hour (10 combat turns) of performance without these restrictions. A battery can be scaled in size to give any endurance and costs 4 times the equivalent fusion power plant. A TL7 battery is the same size as a TL8 battery.

For example, a TL7 B-rated battery with 2000 hours of endurance will require $(7 \times 2000/1000)$ 14dT and cost $(16 \times 2000/1000 \times 4)$ 108MCr

The time to recharge a battery is equivalent to the battery endurance used (in low power setting) divided by 1000 then multiplied by 2. If using solar panels to recharge the battery, the "power plant rating" is 0.1.

For example, the battery described above has been used for 1600 hours. To recharge it with solar panels will require $(1600/1000/0.1 \times 2)$ 32 hours.

Capital Ship Maneuver Drive Selection

Capital ships have different drive selection criteria, which will depend on the tonnage size of the hull. Any one drive will be less efficient as the tonnage it must drive increases resulting in a lower maximum thrust value. Note that at the tonnage interface between a Capital Ship and a Non-Capital Ship, drives can often be smaller but more expensive or sometimes even cheaper. This overlap is due to pricing structure variations between the modular (drop-in) components used in Non-Capital Ships and the customized drives used for Capital ships.

To determine the tonnage of the drive required, refer to the Capital Ship Maneuver Drive Potential Table, which will provide the percentage of the ship's tonnage that must be applied to a drive to provide the desired thrust. Capital ship maneuver drives cost 0.5Mcr per dT.

Capital Ship Maneuver Drive Potential Table

Thrust (G)	1	2	3	4	5	6
% of displacement	1	1.25	1.5	1.75	2.5	3.25

Capital Ship Power Plant Selection

For Capital ship power plant selection, the tonnage required will depend on the required power plant number, with the cost of the power plant modified by the type to be installed.

Capital Ship Power Plant Table

Rating	1	2	3	4	5	6
% of displacement	1.5	2	2.5	3	4	5

Capital Ship Power Plant Cost Table

Power Plant Type	Cost/dT (Mcr)
Chemical	1.25
Fission	1
Fusion (TL8 – 10)	2
Fusion (TL11+)	2.5

The power plant rating must be at least equal to either the maneuver drive or the Zimm Drive rating, whatever is higher. The power plant rating will also determine what weapons and at higher tech levels, what defensive screens can be installed.

For example, a 2,500dT cruiser constructed at TL12 with a power plant rating of 5 may have up to 12 bay weapons $5 \times 2500/1000 = 12.5$ rounded down to 12. It can have 1 meson screen and 1 nuclear damper.

Capital Ship Armament Power Table

Power plant rating	Turret Weapons	Bay Weapons	Spinal weapons	Screens
1	Unlimited by Power	1 per 1000dT	No	1
2	Unlimited by Power	2 per 1000dT	Yes	1
3	Unlimited by Power	3 per 1000dT	Yes	1
4	Unlimited by Power	4 per 1000dT	Yes	1
5	Unlimited by Power	5 per 1000dT	Yes	1
6	Unlimited by Power	6 per 1000dT	Yes	1

Zimm Drive

To determine which drive letter to use for a Zimm Drive consult the chart below.

Zimm Drive Letter Chart

Hull	100	200	300	400	500	600	700	800	900	1000	1200	1400	1600	1800	2000
Drive	A	B	C	D	G	H	J	J	K	K	L	M	N	P	Q

For Capital Ship class vessels between 2001 and 5000 tonnes, a Zimm Drive will require 3% of the ship's tonnage and cost 2MCr per tonne of drive. Zimm Drives cannot be installed on vessels smaller than 100 tonnes.

System Redundancy

The same component can be installed multiple times – a ship can carry a backup computer, a backup power plant and so forth. Only one such system can be used at any time, with the exception of armaments. Backup systems come online automatically when the primary system is disabled. Once all backup systems have been disabled, further hits start destroying systems, starting with the primary system.

Non-Capital Ship Drive Costs

Code	Z-Drive		M-Drive		P-Plant	
	Tonnes	MCr	Tonnes	MCr	Tonnes	MCr
A	10	10	2	4	4	8
B	15	20	3	8	7	16
C	20	30	5	12	10	24
D	25	40	7	16	13	32
E	30	50	9	20	16	40
F	35	60	11	24	19	48
G	40	70	13	28	22	56
H	45	80	15	32	25	64
J	50	90	17	36	28	72
K	65	100	19	40	31	80
L	60	110	21	44	34	88
M	65	120	23	48	37	96
N	70	130	25	52	40	104
P	75	140	27	56	43	112
Q	80	150	29	60	46	120
R	-	-	31	64	49	128
S	-	-	33	58	52	136
T	-	-	35	72	55	144
U	-	-	37	76	58	152
V	-	-	39	80	61	160
W	-	-	41	84	64	168
X	-	-	43	88	67	176
Y	-	-	45	92	70	182
Z	-	-	47	96	73	192

Non-Capital Ship Drive Potential Table

	100	200	300	400	500	600	700	800	900	1000	1200	1400	1600	1800	2000
A	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
B	4	2	1	1	-	-	-	-	-	-	-	-	-	-	-
C	6	3	2	1	1	1	-	-	-	-	-	-	-	-	-
D	-	4	2	2	1	1	1	1	-	-	-	-	-	-	-
E	-	5	3	2	2	1	1	1	1	1	-	-	-	-	-
F	-	6	4	3	2	2	1	1	1	1	1	-	-	-	-
G	-	-	4	3	2	2	2	2	1	1	1	1	-	-	-
H	-	-	5	4	3	2	2	2	2	2	1	1	1	-	-
J	-	-	6	4	3	3	2	2	2	2	2	1	1	1	-
K	-	-	-	5	4	3	3	3	2	2	2	2	1	1	1
L	-	-	-	5	4	3	3	3	3	3	2	2	2	1	1
M	-	-	-	6	4	4	3	3	3	3	3	2	2	2	1
N	-	-	-	6	5	4	4	4	3	3	3	3	2	2	2
P	-	-	-	-	5	4	4	4	4	4	3	3	3	2	2
Q	-	-	-	-	6	5	4	4	4	4	4	3	3	3	2
R	-	-	-	-	6	5	5	5	4	4	4	4	3	3	3
S	-	-	-	-	6	5	5	5	5	5	4	4	4	3	3
T	-	-	-	-	-	6	5	5	5	5	5	4	4	4	3
U	-	-	-	-	-	6	6	5	5	5	5	4	4	4	4
V	-	-	-	-	-	6	6	6	5	5	5	5	4	4	4
W	-	-	-	-	-	-	6	6	6	5	5	5	4	4	4
X	-	-	-	-	-	-	6	6	6	6	5	5	5	4	4
Y	-	-	-	-	-	-	6	6	6	6	5	5	5	4	4
Z	-	-	-	-	-	-	6	6	6	6	6	5	5	5	4

Fuel

Total fuel storage for a ship must be shown on the design plans. Providing fuel tankage has no cost but the capacity of fuel tankage will determine how frequently a ship is required to refuel.

Both standard power plants and Zimm Drives use hydrogen as a fuel but will use that fuel at differing rates.

Zimm Drives

The fuel used by a Zimm Drive for a standard two parsec transition can be calculated by the following formula.

$$F = H \times F_m$$

F = Fuel required in tonnes (dT)

H = Tonnage of hull (dT)

F_m = Fuel Multiplier (see table below)

For example, a 200-tonne ship would require 200 x 0.2 = 40dT Fuel

A Zimm Drive can also enable a starship to make smaller transitions of less than 100 AU with negligible fuel use. Allowing tankage space for the additional fuel to make skip-transitions is a common design practice. System defense boats can also be designed with Zimm Drives and enough fuel capacity to undertake skip-transitions using in-system Zimm points.

Zimm Drive Transit Times and Fuel Requirement

Distance Covered	Time Spent in ZimmSPACE	Fuel Multiplier (Fm)
1 AU	1.44 seconds	0.000000047
10 AU (approx. distance to a nearby gas giant)	14.40 seconds	0.00000047
77 AU (approx. distance to outer edge of solar system)	1.85 minutes	0.000003619
1 Light Year	26 hours (1.08 standard days)	0.03
1 Parsec (or 1 hex on a star map)	84 hours (3.5 standard days)	0.1
2 Parsecs (or 2 hexes on a star map)	168 hours (7 standard days)	0.2

Zimm Drive Emitter Nodes

To allow the generated Zimm quantum field bubble to project out beyond the hull to encompass the entire ship, Zimm Drive emitter nodes are installed in an array across the hull of the ship. When inactive, the nodes are retracted into recesses sealed by hull plating and armour. When the Zimm drive is energized, the recess covers retract, and the nodes extend outside the hull surface to project the Zimm quantum field. Emitter nodes and their recess housings are included in the cost of the Zimm Drive.

If the ship's hull suffers damage through combat action or an accident, the ability to generate a stable Zimm quantum field bubble reduces. Depending on the degree of the reduction of field stability, the ship might complete transit with drive failure occurring before arriving at the destination or simply not transiting into Zimm space at all.

For every 10% of the ship's available hull points that are lost due to combat or accident there will be a DM-1 applied to make a successful Transit roll. However, a ship with more than 60% of its Zimm Drive emitter nodes not functioning will not be able to make a transit.

Zimm Drive Recharge Time

Creating the conditions for the formation of a stable Zimm quantum field bubble for any starship will take time. This time period is fixed by the quantum physics of the Zimm Drive and remains constant for all starship hull sizes.

A starship must charge or recharge its Zimm drive for a period of no less than eight hours before being able to make a transit into Zimm space. This time allows the Zimm Drive to form a stable bubble when energized and the drive will not function at all if not charged fully.

Military grade Zimm Drives are much more robustly constructed with heavier capacitors and more efficient field emitters enabling recharge in five hours. A military grade Zimm Drive costs 50%

more than a standard Zimm Drive of the same type. Selection of military grade Zimm Drives must be noted during the ship design process.

Maneuver Drives

Gravitic drives require no fuel to operate. However, a reaction drive requires reaction mass to operate. See module 3 on page 152 for reaction drive reaction mass requirements.

Non-Capital Ship Power Plants

The amount of fuel required by the power plant is determined by the rating of the power plant and the length of the ship's operation. The table below lists the amount of fuel needed to power the ship for two weeks, which is the bare minimum for a Zimm-capable starship.

Power Plant	Power Plant Fuel																											
	A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q	R	S	T	U	V	W	X	Y	Z				
Tonnes of Fuel Per 2 Weeks	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48				

Capital Ship Power Plants

Capital ship power plant fuel is calculated differently than smaller naval or comparable civilian vessels. For a standard fusion power plant, the fuel required to power the ship for two weeks of operations is two thirds of the power plant tonnage.

For example, the 100 tonnes power plant of a Hub Federation Navy Moltke-class cruiser will require 66 tonnes of fuel for two weeks of operations.

Power Plant Fuel Cells

A very recent technological development, power plant fuel cells are still very uncommon in Clement Sector. Based on technical papers arriving from Earth Sector in 2331, just before the Conduit collapse, fuel cell technology availability is limited to the core subsectors and then only at populous, high technology systems.

A typical fusion power plant requires fuel allocation equal to 10% of their size (rounding up with a minimum of 1 tonne). Unlike chemical and fission power plants, fusion power plants use fuel cells that provide enough fuel for a single year. Once exhausted they must be replaced at a starport or dockyard, usually undertaken during annual maintenance.

The standard one-year operational duration can be extended by increasing allocated fuel cell space to provide enough fuel for the required extended duration. This is especially useful for long range scout vessels undertaking extended duration exploration missions.

Fusion Power plant fuel cells can only be refueled at specialist facilities located only at Starports with classifications A to C. Recycled fuel cells can be found for purchase and are less

expensive but have an operational life of around ten months and increase the risk slightly for a power plant failure. Even with this being the case, it does not stop ship captains from using them.

Yearly cost for fuel cells is 12,000Cr per tonne. Recycled fuel cells will cost between 20-25% less. Power plant fuel cells can only be used as an alternative to the standard power plant fuel requirements. They cannot be used to supplement or provide additional power plant fuel.

Environmental Control

Comprising two distinct important sub-systems operating together to provide a livable, sustainable environment for a space vessel's crew and passengers. Losing either system due to component failure or damage constitutes a significant danger to any space vessel.

Almost all system governments within Clement Sector have very strict safety regulations defining minimum standards for environmental and life support systems. Ships that fail to meet these standards will be served a defect order by that system's safety authority or impounded until the defects are resolved.

Monthly life support costs for both environmental and life support systems are covered on page 43. These costs include replacement parts and servicing.

Environmental

An essential part of any space vessel, environmental is more than a convenient location of the ship set aside to store the vessel's organic waste. Rather, it is an essential part of that vessel's life support system, bringing together waste recycling, waste reclamation and purification, including water.

Advances in technology ensure that environmental systems improve in efficiency, reducing the size of the reclamation tanks and purification units. However, the "moles" or environmental/life support techs (so named because they spend time within crawl spaces between decks) job remains the same.

Below TL10, environmental requires a minimum space requirement of 2 tonnes with an additional 0.5 tonnes per 25 crew and passengers. From TL10, the minimum space requirement is 2 tonnes and 0.5 tons per 50 crew and passengers. Cost for an environmental space is 1MCr and 0.25MCr per additional tonnes.

Life Support

Simply put, no life support, no survivability of a ship's crew. A vessel's life support system provides a constant viable atmosphere, provides appropriate levels of replenishment/recycling, and provides variable heating as required.

Life support is a complex system installed throughout a space vessel allowing for flexible adjustments of environment throughout any part of the interior. Extractors remove by-product gases to filters and processors to be recycled back into the ships closed environment. It is a different sub system to Environmental but still extensively linked to it.

A ship's Life support plant requires a minimum space requirement of 2 tonnes with an additional 0.25 tonnes per 25 crew and passengers. Cost is 1.5MCr and 0.25MCr per additional tonne.

Design example – The Engineering Section

Selecting a maneuver drive type C and a power plant maneuver drive type C from the Drive Cost table gives the trader an operational thrust of 3G. A 200dT hull requires a Zimm Drive type B.

Drives:

Maneuver drive type C = 5dT costing 12MCr.

Power Plant type C = 10dT costing 24MCr.

Zimm Drive type B = 15dT costing 20MCr.

Fuel requirements for the trader:

Zimm Drive = $(0.1 \times \text{hull size}) \times 2 = 0.1 \times 200 \times 2 = 40\text{dT}$

Power Plant Fuel table specifies 6dT of fuel required for 2 weeks operations

Engineering Section summary: Allocation = 76dT, Cost = 56MCr.

3. The Main Compartment

The ship's main compartment contains all non-engineering features of the ship, including the bridge, ship's computer, sensors, accommodation, armament, small craft hangars, the cargo hold and other items.

Bridge

All ships must have a bridge containing basic controls, communications equipment, avionics, scanners, detectors, sensors, and other equipment for proper operation of the ship. The size of the bridge varies depending on the size and the role of the ship. The cost for a bridge is 0.5MCr per 100dT of ship.

Ship Size (dT)	Standard Bridge Size
100 - 200	10
300 - 1000	20
1001 - 2000	40
2001 - 3000	60
3001 - 5000	80
5001 - 8000	90
Greater than 8000	100

The bridge is the nerve center of the ship and is vital to on-board operations. Bridge layout will vary from ship type to ship type and how much space allocation is required. Typically, a military vessel places the captain in the middle with all bridge workstations surrounding that position to maximize tactical and command flexibility. Free trader vessels might even have the accommodation areas sharing the same space as the bridge to maximize cargo capacity.

The allocation for a bridge also can be used to provide a day cabin for the captain, bridge crew fresher and galley and for military vessels, a secondary bridge or CIC (Command Information Center).

Secondary Bridge – Command Information Center

The secondary bridge is a fully functional but more compact bridge that is primarily designed to provide a backup for a warship's bridge in the event that the bridge has been damaged or destroyed during combat operations. Further, the secondary bridge will act as a communication and information hub when in combat and is the warship's executive officer's station during alert periods and during combat. Space for the secondary bridge is taken from standard bridge allocation and cannot exceed 25% of that allocation. They cannot be installed into warships with hull sizes less than 1000 tonnes.

Command Bridge

Warships that will be coordinating the efforts of a squadron of other vessels require a command bridge. Command bridges incorporate large scale holographic display of fleet actions, enhanced communications and control electronics, and space for more command staff in a larger

bridge space that incorporates both the ship's bridge and Flag Bridge. The two sections of the command bridge may be separated and placed in different areas of the ship, but for command efficiencies both tend to be adjacent to each other. A spacecraft command bridge requires an allocation of an additional 50% and costs 50% more than a standard bridge for the given tonnage but gives a +1 DM to Tactics (naval) checks. A command bridge replaces the standard ship's bridge.

Compact Bridge

A compact bridge crams as much equipment and control stations into as small a place as possible. Compact bridges take up 25% less tonnage than a standard bridge of the same type and costs 10% more than a standard bridge of the same type. However, all skill checks performed on the bridge suffer a –1 DM due to the un-ergonomic design.

Hardened Bridge

A hardened bridge is shielded against the effects of nuclear missile detonations and meson gun impacts. The ship's computer systems are immune to EMP and the number of rads absorbed by the bridge crew is reduced by 1000. Hardening a bridge adds 25% to the cost of the bridge. If a ship has radiation shielding installed, it is assumed to be hardened.

Holographic Controls

This bridge design incorporates advanced interactive holographic displays which reconfigure to adapt to the current situation. Indeed, more sophisticated systems available for both civilian and military use include the ability for the ship's computer to assume a holographic avatar to interact with the ship's captain and bridge crew (additionally requires Intellect software). A bridge with holographic controls is always optimized and gives a +2 bonus when rolling for Initiative. A holographic bridge adds 25% to the cost of the bridge.

For Avatar Interface selection criteria and requirements, refer to page 106-107.

Bridge Types

Type	Requirements
Secondary (CIC)	From standard bridge allocation. No greater than 25%
Command	50% size increase/50% cost increase, +1 DM Tactics (Naval)
Compact	25% size reduction/10% cost increase -1 DM skill checks
Hardened	25% cost increase, 1000 rad reduction to crew. EMP immune
Holographic Controls	25% cost increase, +2 initiative, ship's avatar (requires Intellect)

Computers

All spacecraft need some form of computer which is usually installed adjacent to the bridge. A computer is identified by its model number and the computer table below indicates details of price, capacity, and tech level at which the first model becomes available. A larger computer will be more advantageous in combat situations which for a civilian vessel fall outside of normal ship operations. Ship's software options can be found on page 105.

For more information on how the rating of a computer and the operation of a computer works, please refer to Independence Games' Clement Sector page 337.

Computer	TL	Rating	Cost
Model 1	7	5	30,000 Cr
Model 2	9	10	160,000 Cr
Model 3	11	15	2 MCr
Model 4A	12	20	5 MCr
Model 4B	12	25	10 MCr

Zimm Control Specialization (bis)

A computer's rating can be increased by 5 for the purposes of running Zimm Control programs only. This increases the computer's cost by 50%.

Hardened Systems (fib)

A computer and its connections can be hardened against attack by electromagnetic pulse weapons. A hardened system is immune to EMP but costs 50% more.

Both options can be applied to the same computer by doubling its cost (+100%).

Capital Ship Computers

Capital ships have multiple distributed computer networks, but always include a central computer core that not only controls the Zimm Drive but also the ship's essential systems. The rating of this central core depends on the size of the ship. Capital ship computers are assumed to have their tonnage included in the bridge allocation of the ship.

Regardless of whether a vessel is Zimm capable or simply an in-system vessel, the rating for the ship's computer system is in addition to the Zimm Control programs software and hardware processing power and speed, allowing other essential ship's system software to be installed. For a capital ship capable of Zimm transits, Zimm Control software is included in the price of the computer system.

Computer Model	Ship Size Minimum (dT)	TL	Rating	Cost (MCr)
Core/3	2000 - 5000	9	40	12
Core/4	5000 – 10,000	10	50	30
Core/5	10,000 – 20,000	11	60	30

Sensors and Communications

A ship will come with a basic communications, sensor, and emissions control electronics suite, but, if required, more advanced systems can be installed. The Dice Modifier applies to jamming and counter jamming attempts.

System	TL	DM	Includes	Tonnes	Cost (MCr)
Standard	8	-4	Radar, Lidar	Included in bridge	Included in bridge
Basic Civilian	9	-2	Radar, Lidar	1	0.05
Basic Military	10	+0	Radar, Lidar, Jammers	2	1
Advanced	11	+1	Radar, Lidar, Densitometer, Jammers	3	2
Very Advanced	12	+2	Radar, Lidar, Densitometer, Jammers, Neural, Activity Sensor	5	4
Survey Sensors	12			10	10
Improved Signal Processing	11	+2		1	4
Distributed Arrays	11		Triples tonnage and cost of sensor suite it is applied to (see description)	x3	x3
Extended Arrays	11		As above	x3	x3
Improved Signal Processing	11	+2		1	4
Lifeform Scanner	12			1	2
Mail Services Array	10			5	15
Mineralogy Suite	11		Can be added to any suite with a densitometer	5	
Rapid Deployment Extended Arrays			Triples tonnage and 5x cost of sensor suite it is applied to	x3	x5

Survey Sensors

Survey sensors integrate a suite of probe drones and deployable satellites into the sensor system and are optimized for scanning large areas at great speed. Survey sensors are equivalent to Advanced Sensors but reduce the time taken to scan a planetary surface by one step.

Sensor Upgrades

Any sensor suite may be upgraded with a range of options to improve likelihood and quality of information and the range at which objects may be detected.

Improved Signal Processing

Signal processing consists of extremely specialized computers and software to improve the quality and likelihood of detection. Improved signal processing provides a +2 DM to sensor tasks and improves of range band of “full” and “limited” by 1 for radar, lidar and densitometer as well as thermal and visual sensors. However, this comes at a cost of increased vulnerability to jamming, with all jamming DMs doubled.

Distributed Arrays

By using multiple hull mounted arrays in an integrated computer-controlled arrangement, it is possible to increase the effective sensor antenna size and increase the longest range of the sensor (all increased range performance is at “minimal” level of detail). Visual and Thermal sensors can now detect at Very Distant Range (from 150,000 to 300,000km), EM and active radar/lidar to Distant range (50,000–150,000km) and passive radar/lidar to Long range. This modification cannot be added to standard sensors and can only be added to ships of 5,000 tonnes displacement or more. Due to their surface area requirements only one sensor suite per craft can be fitted with distributed or extended arrays.

Extended Arrays

An extended array is identical to a distributed array, but because the arrays are extended well beyond the hull of the ship on retractable arms, there is no limit on the size of the ship. However, with the arms extended the ship can be detected at a +2 DM by all sensors bar NAS and it may not use its maneuver or Zimm drive.

Design plans for ships will often allocate reserve tonnage to allow for future sensor upgrades or other uses such as in installing fire control for weapons.

Lifeform Scanner

Specifically designed to detect signs of life and being able to determine what that lifeform is. A lifeform scanner can identify sentient lifeforms or different groups of animals as small as insects. Typically used by survey and exploration vessels once in high orbit above a newly discovered world the scanner can identify and quantify population densities, possible life types (sapient, sentient, non-sapient etc.), and other ecosystems within 24 hours.

A Sensors check is required to successfully use a lifeform scanner and to then interpret the scan results. It is not 100% accurate and typically has an accuracy of between 70% and 85% which provides a sufficiently detailed initial bio-survey prior to more detailed surveys.

Mail Services Array

Dealing with electronic mail data loads is beyond the capability of standard ship communication system due to the high data load requirements. To overcome specialized mail couriers and similar ships will mount a specialized communications array specifically for handling those data streams. The TL 10 mail services array is standard installation on all Hub Federation Postal Service mail couriers.

Mineralogy Suite

Any sensor system that has a densitometer may be upgraded with this suite so as to determine types of minerals present and their quantities.

Rapid Deployment Extended Arrays

This system works in the same way as an extended array, but it can be deployed and retracted within a few seconds, allowing a ship to use its maneuver and jump drives within the same combat round. Rapid deployment extended arrays triple the tonnage and multiply the cost of the sensor suite they are attached to by five.

Design example – The Main Compartment – Bridge, Computer and Sensors

A standard bridge along with a Model 2bis computer will be installed, the *bis* upgrade providing space for the Zimm Drive software. For the trader, a basic civilian sensor suite will be installed.

Bridge (standard) = 10dT costing 0.5MCr per 100dT hull size = $0.5 \times 200/100 = 1\text{MCr}$.

Computer Model 2bis = 0.16MCr + 50% computer cost = $0.16\text{MCr} + 0.08\text{MCr} = 0.24\text{MCr}$.

Sensors (Basic Civilian) = 1dT costing 0.05MCr.

Main Compartment – Bridge, Computer and Sensors: Allocation = 11dT, Cost = 1.29MCr.

Accommodation

Steerage

Rather than using low berths, the cheapest means of accommodation for passengers on space vessels is steerage. Commonly found on very low-cost transport vessels it is quite often a converted cargo hold or a converted space towards the stern of a ship, steerage is very cramped providing little privacy. Many systems in Clement Sector consider steerage accommodation to be in breach of various transport regulations and health and safety guidelines.

Steerage accommodation can be either large open dormitory spaces like barracks, some space with some form of partition wall erected to form very small staterooms providing some privacy for the occupants (usually families) or a combination of both.

Each steerage passenger requires 1dT at a cost of 0.05MCr each regardless of petitioned or open steerage accommodation. Partitioned steerage spaces are no greater than 2dT in displacement containing two double bunks and limited locker space. Steerage life support costs 2000Cr monthly for every 20dT of steerage accommodation space allocated.

Regardless of steerage accommodation type both head facilities and some form of common and galley space must be provided. These are determined using the relevant guidelines in this publication.

Steerage accommodation should never be used for standard crew or carried troop accommodation; however, it is certainly not unknown for some system governments to use steerage accommodation to transport a greater number of troops than would normally be carried by more appropriate accommodation.



Standard Staterooms

Quarters for the crew and passengers are provided in the form of staterooms containing sleeping and living facilities. Each stateroom is sufficient for one person, displaces 4 tonnes, and costs 0.5MCr. Staterooms are designed to be able to be double occupied and cannot contain more than two persons due to the strain it would place on the ship's life support equipment. The tonnage and cost of the staterooms includes the life support systems needed to keep the crew alive.

Typically, a standard stateroom is reduced to a displacement of 3dT, with the remaining 1dT providing space for corridors and recreation facilities. For middle class passengers, the stateroom is a typical accommodation, which can be either shared or single occupancy.

A stateroom can be designed to a minimum size of 2dT, providing an additional 2dT space for corridors and recreation facilities. When a stateroom is reduced to this size, no fresher facilities are provided within the stateroom and occupants must use external head facilities. This arrangement is very common on naval vessels.

High Class Staterooms

For those that can afford luxury travel on specialized star liners or luxury yachts, then appropriate accommodation of appropriate standard needs to be available. High class staterooms contain full bath facilities, separate sleeping rooms, a living room, connecting corridors and other common spaces. They can accommodate four passengers in high class comfort. A typical high-class staterooms displace 8dT and costs 1MCr. Life support cost for a high-class stateroom is 5000Cr per month.

Crew Berthing

Unlike civilian vessels that provide accommodation for crew and passengers alike in standard staterooms, enlisted crews for naval vessels are accommodated in berths. A typical berth accommodates up to eight crew members, displaces 6dT and costs 0.5MCr. The tonnage and cost of the berth includes life support but does not contain fresher facilities.

Barracks

Similar to Crew Berths, barracks can be provided for ships that carry a large number of troops intended for boarding or assault operations. A barracks displaces 2dT per marine at a cost of 0.1MCr each and includes heads and common areas. A barracks can also be used in ships that carry colonists or prisoners.

Heads

For naval vessels and even some civilian vessels, the head is a standard fitting. These are self-contained fresher facilities located outside berths or staterooms. There are two types:

- Toilet facilities only, displacing 1dT and costing 0.05MCr.
- Toilet and shower facilities, displacing 1.5dT and costing 0.1MCr.

A ship's head is often combined into larger facilities of two, three or even single units. The number of heads required for a ship is typically one head per four crew members but up to a maximum of eight crew can be allowed for.

Low Passage Berths

A low berth is a cold sleep transportation unit for carrying passengers and is commonly installed on ships as a very low-cost form of travel. Low berths also serve well in emergencies in that they can provide suspended animation facilities for characters when medical care, rescue, or assistance is not immediately available.

There are two types of low berth facilities available:

- A Standard low berth carries one low passenger, displaces 0.5dT and costs 0.05MCr
- Emergency low berths do not carry passengers, but can be used for survival, displaces 1dT and costs 0.1MCr. Each emergency low berth can hold up to four persons.





Internal Components

There are a variety of options available for a designer to further customize a ship. These options range from crew and passenger facilities to additional safety and security features.

Additional Airlock

Airlocks are sealed systems consisting of two heavy-duty doors or iris hatches, with atmospheric pumping equipment, allowing transit to and from a spacecraft in a vacuum or hostile atmosphere. A ship may have one airlock for every 100 tonnes or part of. A standard airlock is capable of cycling two humans per minute exiting or entering the ship.

Additional airlocks of any size may be added to a ship. It typically takes a minute for an airlock to fully cycle. Airlocks require a minimum displacement of one tonne and cost 0.1MCr per dT.

Armory

Far more specialized than a ships locker and generally installed in military ships only, a ships armory contains a wide variety of weapons which can only be accessed by those with the correct codes (usually the ship's senior officers, security team or the marine officers). In game terms, an armory has enough snub pistols for the crew, enough long arms for any marines, and a selection of other military equipment like grenades, combat drug packs, combat armor and communications equipment. An armory displaces 2dT and costs 0.5MCr.

For a navy vessel, the number of armories to be included in the ship's design is based on the crew and marine complement. One armory is installed for every 50 crew members, or every 10 marines, in order to provide adequate storage for equipment, weapons and ammunition.

Astrographic Cartography Room

Commonly known as the "chartroom", the astrographic cartography room is a commonly installed facility on scout or exploration vessels. Most often these specialized mapping rooms, making use of extensive holographic imaging systems, are located adjacent to or installed as part of the ship's bridge.

If a ship has a chartroom installed the vessel's astrogator receives a +1 DM for any higher-than-average astrogation related task. The chartroom requires a space of 2dT at a cost of 2MCr.

AutoDoc

The autodoc is a compact but more expensive alternative to a medical bay that can be installed on smaller vessels or to increase medical facility flexibility on bigger vessels. The effectiveness of an autodoc depends on the tech level and displaces 0.5dT at a cost of 0.5MCr.

At TL 10, the autodoc has a medical skill of 1, which increases by 1 at TL 12. For diagnostic purposes the autodoc has an effective EDU of 10, while effective DEX for surgical treatment is 9.

Briefing Room

A more specialized component, not generally required on adventure class ships, the briefing room is a useful addition to a mercenary vessel to be used by tactical or business teams to discuss operational plans or meet with clients. All military vessels will have at least one briefing room with additional briefing rooms determined by the size, class, and role of the ship. Capital ships require one briefing room per section of ship and one briefing room per 20 fighter or bomber small craft. Ships with command bridges and fighter squadrons require additional briefing rooms and facilities.

They should not be confused with a theater which can also be used for larger scale briefings. A briefing room gives a +1 DM to Tactics (Military or Naval) checks made when planning missions on board ship. Briefing rooms require a space of 4dT at a cost of 0.5MCr.

Casino

A recreation and entertainment option for spaceliners, starliners and casino ships the onboard casino has all the features and options expected for such a facility. An allowance of 1dT per expected patron must be provided at a cost of 0.5MCr. The space cost per allowance allows for all casino equipment and bar facilities.

It is also a common practice to include additional recreation space which is utilized for more comprehensive bar and galley facilities. Additional space for these can be calculated using the high-class dining guidelines on page 57. Supplies for a casino up to 8dT cost 10,000Cr per month and those over 8dT cost 15,000Cr per month.

Chapel

There are a multitude of cultures and belief systems throughout colonized space, and it is useful for a starship designer to provide space for crew members or passengers to practice their religious beliefs or even to simply seek a quiet place to be alone with their thoughts. The chapel can be configured as required by the user(s) to suit their particular belief system. A chapel displaces 2-4dT at a cost of 0.2MCr per displacement tonne used.

Commissary or Supply Officer's Store

A part of naval establishments and warships since the age of sail is the commissary. This facility allows for crew to purchase a multitude of items at duty free prices, such as new uniform replacements (beyond their normal allocation), foodstuffs, personal hygiene, personal electronics, and other items. The commissary is typically found adjacent to or part of the Supply Officers' office and can be self-serve with cashier or front desk operated.

Commissaries are only found on ships of more than 600 tonnes displacement and require a space of 0.25dT per five crew members (minimum space must be 1.5dT) with an additional 1dT for the admin section. Cost is 0.1MCr per dT.

Crew Recreation/Officer's Lounge

Providing facilities for the crew to relax and socialize away from the noisier mess or wardroom areas is essential for vessels with more than ten crew or passengers that are away for periods of longer than three weeks. For crew, determine the total number of those who are off watch (assume three watches for military and commercial vessels) when calculating the space required. These facilities require a space of 0.2dT per person and cost 0.2MCr per dT.

Fuel Scoops

Whereas streamlined ships have fuel scoops included in the hull cost, unstreamlined ships require fuel scoops added to the design to be able to gather unrefined fuel from a gas giant. Adding scoops does not require tonnage and cost 1MCr.

Fuel Processors

Fuel processors convert unrefined fuel into refined fuel. A 1dT fuel processor unit which costs 0.05MCr can convert 20dT of unrefined hydrogen into refined fuel per day.

Galley

A galley is an area set aside for the preparation of food and beverages. On smaller vessels this area tends to be a small open space adjacent to the ships common room. For larger ships carrying passengers or for navy vessels, a galley is a separate area though still adjacent to the officer's wardroom, crew mess or passenger lounge. A galley requires 0.25dT per crewmember and costs 0.25MCr per dT.

Gardens

Hydroponic gardens and recreational gardens provide for different purposes but essentially have the same considerations for size and cost.

A hydroponic garden provides fresh produce for crew and passengers to supplement or even entirely replace the shipboard victuals normally supplied when a vessel replenishes. A hydroponic garden requires a specialist crew member with Animals (Farming), Trade (Gardening*) or Trade (Hydroponics) skill for every 4dT of space allocated. Most shipboard gardens planted to grow foodstuffs are arranged vertically using a mix of hydroponic and soil planting to utilize the maximum space available. Each tonne of space allocated for this purpose, by providing fresh produce, will reduce a single stateroom (all) and crew berth's monthly life support by an additional 100Cr. For third class and barracks, divide the tonnage allocated by five to determine the tonnage of gardens to obtain the same cost reduction.

Recreational gardens provide scenic park land for recreation and relaxation. A recreation garden on a space station or outpost can even be large enough to provide for sporting facilities and lakes. As for a hydroponics garden, a recreational garden will require a specialist crew member with Trade (Gardening*) or Trade (Hydroponics) skill for every 4dT of space allocated. Gardens cost 0.25MCr per 1dT allocated with a minimum size requirement of 4dT.

*Trade (Gardening) - Skilled in the design, creation, and maintenance of ornamental and recreational gardens.



Gymnasiums

Gymnasiums can be found in many vessels. Most often they are impromptu areas set aside as part of the crew recreation area, however a formal area can be set aside as part of the design. Gymnasiums allow the crew and passengers to pursue exercise regimes to maintain fitness and health. A fully equipped gymnasium usually displaces 4dT at a cost of 1MCr. However, if space aboard ship is tight, 2dT can be re-allocated to general recreation. Cost remains the same.

High Class Dining

High class dining provides a true fine dining restaurant facility varying in size depending on the number of patrons it is designed to serve. Each provided seat in a high-class dining room displaces 0.25dT at a cost of 0.25MCr and a steward is required per every ten diners. Size and cost provide for dining area, kitchen area, bar facilities and sometimes even a dance floor and entertainment stage. Supplies for a high-class dining area will cost 10,000Cr per month.

Interrogation Room

Usually placed adjacent to the ship's brig, the interrogation room is a small space provided for debriefing or interrogation of prisoners and those suspected of wrongdoing.

Equipped for this task, the interrogation room will offer a +1 DM for skilled interrogators attempting any task up to a Difficult level. Small Interrogation rooms require a space of 2dT at a cost of 0.25MCr.

A larger interrogation room will be divided into an observation/monitoring area and inner interrogation area. More comprehensively equipped with more comprehensive detectors and scanners than a small interrogation room, it provides a skilled interrogator a one-step reduction of difficulty for any greater than average task. Space required is 4dT at a cost of 0.75MCr.

Library

Even though all ships have on-board libraries of some degree having a dedicated on-board library is useful for both research and passing time in Zimmspace. A library contains computer files, display screens, holotanks and sometimes even printed books. For its size a library is very expensive but often the benefits to crew and passengers will outweigh the initial cost of having one installed. A library displaces 4dT and costs 4MCr.

Laboratory

Space allocated to laboratories can be used for research and experimentation. An allocation of 4dT of lab space allows for one scientist to perform research onboard ship. Cost for a laboratory will vary depending on the type of research being undertaken and the equipment required for that research but will average out to 1MCr per 4dT of space allocated.

Luxuries

Luxuries cost 100,000Cr per tonne, and make life on board ship more pleasant for passengers and crew. Each tonne of luxuries counts as one level of the Steward skill for the purposes of carrying passengers, and therefore allows a ship to carry middle and high passage passengers without the necessity of having a trained steward as part of the crew.

Medical Facilities

Larger vessels and all naval vessels will have medical bays. These will vary in size depending on available space or the specific role of the vessel. Most civilian ships will usually make do with an autodoc (see above). Medical bays are rated on the number of beds they hold. Each bed has full diagnostic, monitoring and surgical equipment included.

Medical bays with less than four beds will require a crew member with medical skill while medical bays with more than five beds require a qualified doctor and a medically trained assistant. A single bed medical bay requires a space of 2dT. Additional beds require a space requirement of 1dT per bed. A medical bay costs 0.5MCr per bed.

If the total amount of medical beds on a vessel exceeds nine beds, then a medical ward must be installed. A medical ward requires one medical specialist per five beds, one additional senior medical specialist per ward and one qualified doctor per ward. For every hundred beds, a senior doctor must be appointed to manage the wards. Medical ward space and cost requirements are identical to medical bays and a single ward cannot exceed fifty beds.

Provision of isolation medical bays and medical wards will increase the cost per tonne by 50%. A more specialized facility, the Operating Theatre requires 2dT and costs 1.5MCr. A qualified surgical doctor and two medical specialists must be provided for this facility.

Mineral Refineries

To reduce costs and increase productivity some larger mining vessels are also specialized refineries allowing raw materials mined from asteroids to be processed (including smelting) into more refined materials. For such vessels cargo space must also be provided to store any refined metals, precious metals, and other materials until they can be transported to orbital facilities.

TL	Production (tons)	Cost (MCr)	Crew
7	0.5	0.5 per tonne	1 per 10 tonnes
10	1	1 per tonne	1 per 15 tonnes
12	2	2 per tonne	1 per 30 tonnes

Mini Galley

Mini galleys can be installed as required. Essentially a small space with a beverage and food dispensing facilities, a mini galley displaces 1dT at a cost of 0.02MCr.

Personal Armor Maintenance Workshop

Otherwise known as a suit morgue, this workshop is most common on naval warships and troop transports and provides storage and servicing areas for combat armor, boarding armor and vacc suits. Six suits can be stored per 1dT of provided space, which also allows cumulative space for maintenance and servicing. If installed, a personal armor maintenance workshop has a minimum space requirement of 2dT even if the ship's troops or marine contingent is less than ten. Cost is 0.2Mcr per dT.

For example, the space required for a PAMW on a troop transport carrying 150 ground force troops is the number of troops divided by the number of suits per tonnes $150/6 = 25dT$.

If a ship has a PAMW installed, then any higher than average repair or maintenance task undertaken by a suitably skilled crewman or marine receives a +1 DM.

Office

On most naval vessels, offices can be provided for the captain and the executive officer. If the crew of the ship is large enough then offices are also provided for department heads. Civilian ships will sometimes provide an office for the captain only.

For a navy vessel, the number of offices is determined by crew size and the number of personnel per department.

- For a crew size greater than 10, then an office must be provided for the captain.
- For a crew size greater than 30, then an office must be provided for the captain and XO.
- If a department's crew size is greater than 5, then an office must be provided for that department's head.

Typically, an office displaces 2dT and costs 0.2MCr.

Office (Small)

Sometimes all that is needed for an office space is a small "nook" or alcove tucked away adjoining a stateroom or close to other workspaces. Just barely big enough to provide suitable space for a workstation and a chair, small offices are ideal for a multitude of uses on any given vessel.

Small offices can also be assembled to provide a bigger office area such as the administration office of a warship or large merchant vessel. If this option is chosen, then an additional 1dT per four small office spaces is required for access space.

A small office requires 1dT at a cost of 0.05MCr.

Retail Shops

Many large spaceliners and starliners will be designed to include a shopping precinct of some kind providing services and selling a plethora of goods, wares, or souvenirs. Shops will range in size from 2dT to 8dT and cost 0.25MCr per tonne.

Sensors Control

For military vessels or specialized vessels with advanced sensor arrays direct access to the sensors or the data provided by them by specialist crew is required even though the ship's bridge(s) has access to any data feeds from those sensors.

If the space required for the ship's sensors is two tonnes or more, then a space is recommended for a sensor operator manned control area. Additional sensor operator stations can be

added as required so to improve data analysis efficiency. Divide the tonnage required for a sensor suite by two, rounding up, to determine the maximum sensor operators allowed.

A sensor control area requires a space of 2dT at a cost of 1MCr. Each additional sensor operator station adds 1dT at a cost of 0.5MCr.

Ship's Brig

Rarely seen on civilian vessels but common on law enforcement and naval vessels, a ship's brig provides a secure location for crewmembers undertaking disciplinary proceedings or holding prisoners under arrest. A brig cell displaces 1.5dT and costs 0.25MCr.

Ship's Locker

Every civilian ship has a ship's locker, which can be loosely defined as a storeroom with just about everything but the kitchen sink in it. Typical equipment stored within a ship's locker includes protective clothing, vacc suits, weapons ammunition (both personally owned and general issue), compasses and survival aids, and portable shelters. The ship's locker is usually protected by a biometric lock keyed to the ship's officers, displaces 0dT and costs 0.1MCr.

The contents of the locker should be defined by the player whose character owns the ship but at the very least would always contain vacc suits and other useful items.

Small Craft Pilot Ready Room

The pilot's ready room is a compartment allowing small craft pilots on duty to "stand by" or remain close to their craft. For ships such as carriers, the ready room also serves as a briefing room for the pilots and crews by squadron commanders or the Commander Aerospace Group (still known as the CAG).

Typically located adjacent to hangar spaces and launch bays, a ready room will only be installed in a vessel where there are more than four small craft. Ready rooms require 0.5dT per small craft crewmember at a cost of 0.25MCr per dT. Heads for the small craft crews must also be provided as per page 51.

Swimming Pools and Spas

Considered the ultimate luxury, swimming pools can be found on some starships (usually star liners and the most expensive luxury yachts) and most large stations. The space requirement and cost include the equipment required to contain and filter the water. Pool and spa facilities require 0.5dT per user at a cost of 0.5MCr per dT.

Theaters

Theaters are used for larger meetings and for entertainment. Each provided seat in a theater displace 0.25dT at a cost of 0.25MCr. Size and cost provisions factor in required equipment for the function of the theater.

Training Facilities

Navy vessels that carry larger detachments of marines or ships' troops are at a disadvantage compared to troops not stationed in space vessels. To maintain peak combat readiness ships such as assault carriers provide training facilities into their design. Such facilities, available at TL 10, include thicker bulkhead walls around firing ranges to stop stray live rounds, multiple gyms, and preparation rooms.

Training facilities require 2dT per simultaneous user and cost 0.2MCr per dT.

UNREP (Underway Replenishment) System

A system originally developed when the only navies were those serving on the seas of Earth, the UNREP system was adapted for use in space. An UNREP system allows for replenishment and resupply of warships while in motion and is essential to the function of squadrons on deployment. UNREP includes fuel hoses, cargo transfer tubes and other gear to allow transfer of ordnance, freight, and fuel between two ships. Only one ship is required to have the UNREP system.

For every tonne assigned to UNREP a ship can transfer 20 tonnes of fuel, cargo, or ordnance every hour. An UNREP system costs 0.5MCr per tonne.

Workroom

Allocation of workrooms is a space luxury not afforded to warships or merchant vessels but may well be considered for inclusion on a personal yacht or passenger vessel. A workroom provides for pursuit of skills or interests as diverse as the arts to melee combat sports. The Space required for a workroom varies between 2dT - 4dT at a cost of 0.1MCr per dT.

Workshop

Every vessel requires some allocation of space for engineering crew to be able to repair equipment and ship systems or fabricate new components. It includes workspace, tools, and an industrial 3D printer to manufacture new parts and other equipment as needed. A workshop displaces 4 tonnes at a cost of 1MCr.

Component	Tonnes	MCr
Steerage (per passenger)	1	0.05
Stateroom (up to 2 persons)	4	0.5
High Class Stateroom	8	1
Crew Berthing (up to 8 crew)	6	0.5
Barracks (per marine)	2	0.1
Heads		
Toilet only	1	0.05
Toilet and Shower	1.5	0.1
Low Passage	0.5	0.05
Emergency Low	1	0.1
Airlock (per dT). Min 1dT	1	0.1
Armory	2	0.5
Astrographic Cartography Room	2	2
AutoDoc	0.5	0.5
Briefing Room	4	0.5
Casino (per patron)	1	0.5
Chapel (per dT)	2-4	0.2
Commissary (per 5 crew)*	0.25	0.1
Crew Recreation	0.2	0.2
Fuel Scoops		1
Fuel Processors	1	0.05
Interrogation Room		
Small	2	0.25
Large	4	0.75
Gardens	1	0.25
Galley (per crew/per dT)	0.25	0.25
Gymnasium	4	1
High Class Dining (per seat)	0.25	0.25
Library	4	4
Laboratory	4	1
Medical Facilities (per bed)**	1	0.5
Mineral Refinery (see table)		
Mini galley	1	0.02
Office	2	0.2
Office (small)	1	0.05
PAMW (1dT/6 suits, per dT)		0.25
Retail Shops (per dT)		0.25
Sensors Control	2	1.0
Ship's Brig	1.5	0.25
Ship's Locker	0	0.1
Small Craft Pilot Ready Room (0.5dT per crew, cost per dT)		0.25
Swimming Pools & Spas (per dT)	0.5	0.5
Theaters (per seat)	0.25	0.25
Training Facility (per dT)	2	0.2
UNREP System (per dT)	1	0.5
Workroom (2dT – 4dT, per dT)		0.1
Workshop	4	1

*Min 1.5dT plus 1dT administration space.

**A single bed medical bay is 2dT with 1dT per additional bed.

***Additional workstations required are 1dT at 0.5MCr.

Design example – The Main Compartment – Internal Components

Apart for accommodation calculated later, the only internal component items added are a single fuel processor and a one bed medical bay.

Fuel Processor = 1dT (processing 20dT of unrefined hydrogen fuel per day) costing 0.05MCr.

Medical Bay (one bed) = 2dT costing 0.5MCr.



External Components

Exterior components are mounted on the exterior of the hull of a spacecraft.

Aerofins

Extendible aerofins improve a spacecraft's maneuverability within planetary atmospheres, giving a +2 DM to all Piloting checks made in an atmosphere and DMs for any atmospheric operations (Clement Sector, p.440-441) still apply. Aerofins take up 5% of the ship's tonnage and cost 0.1 MCr per tonne.

Breaching Tube

All airlocks include flexible plastic docking tubes that allow passengers to cross from one ship to another by floating through the air-filled tube. A breaching tube is a military version of the common docking tube. Instead of a thin myomer, the breaching tube is made of a combination of ballistic cloth and reflec armor. The breaching tube does not end in a docking collar, but in a magnetic clamp with a ring of plasma torches that can burn through the hull of an enemy vessel when attached.

A breaching tube takes up three tonnes of space and costs 3MCr. To use the breaching tube, the craft must be adjacent to the target vessel and then succeed in a docking action (Clement Sector, page 440). As the vessel does not have to line up with an airlock, this maneuver is easier than using a normal docking tube and receives a +1 DM if the boarding vessel does not want to enter via the airlock.

If access is acquired via an airlock, the plasma torches quickly burn through the airlock and boarding can begin immediately. If trying to get through the hull, the plasma torches will take 1 full turn to cut through, increasing by 1 turn for each 2 points of armor (round down).

Each breaching tube provides 5 armor points against personal and vehicle weapons and 10 armor points against lasers. A hit from a starship weapon will destroy the breaching tube if a successful Point Defense roll is made (Clement Sector, p.420-421).

Docking Clamp

A docking clamp allows a spacecraft to carry a small craft or other vessel on the outside of the hull and allows access between both vessels while they are docked. Recalculate the ship's Thrust Number by adding the tonnage of the spacecraft and the docked craft together, round up to the nearest hull size and then compare that to the thrust by drive volume table. If performance is reduced to the point that it has no rating, then treat the ship as if it has the equivalent of a solar sail. A Zimm Drive must be sized to accommodate the combined displacement of both vessels.

For example, a 200dT transport has a dorsal docking clamp. Attached to the clamp is a 50dT cutter. Together, the vessels have a displacement tonnage of 250, which is rounded up to 300. The 200dT ship has M-Drive B, which gives the combined spacecraft a Thrust of 1G. When the cutter disconnects from the clamp, the 200dt transport will be able to use its normal thrust of 2G.

The size of the vessel that can be docked depends on the size of the docking clamp.

Docking Clamp Tonnage Table

Clamp Tonnage	Attached Ship Maximum	Cost (MCr)
1	10 - 30	0.5
5	40 - 90	1
10	100 - 300	2
20	400 - 2000	4
50	2000 +	8

Grappling Arm

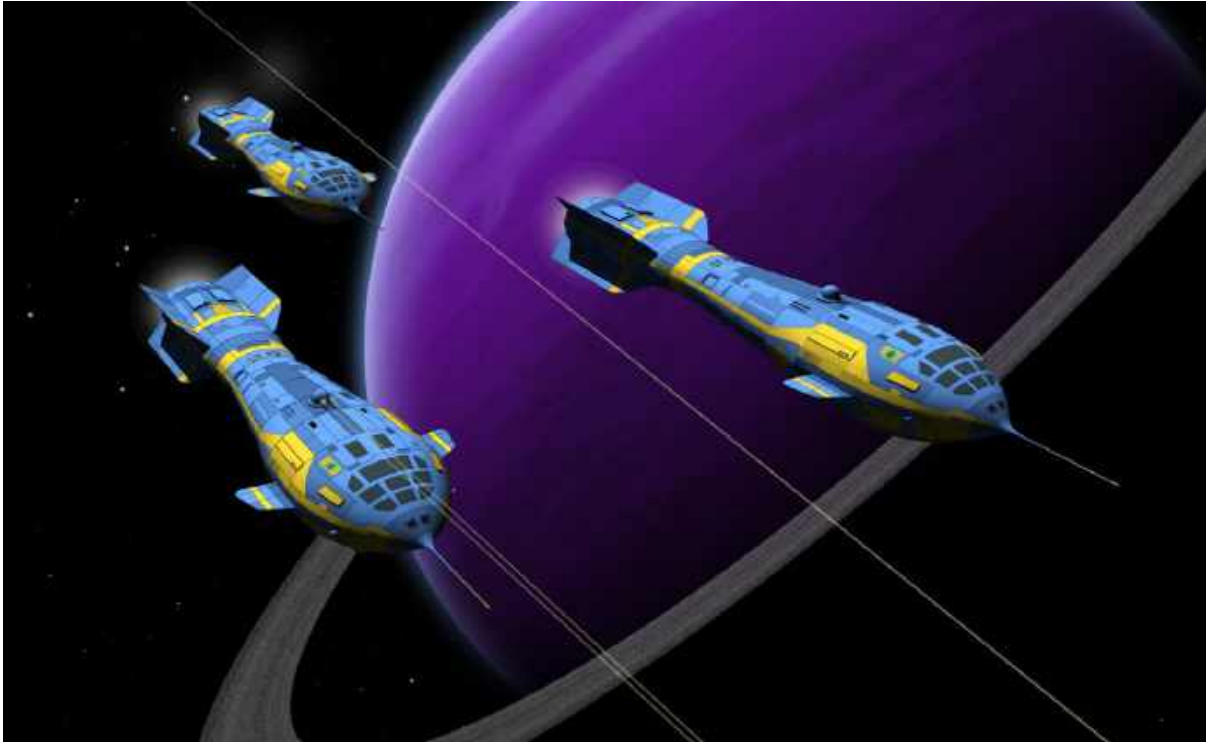
A grappling arm is a remote-control device for picking up or manipulating objects in space. The arm is a flexible tentacle of thousands of telescoping segments, capable of reaching out up to 250 meters and allowing objects of up to two tonnes to be manipulated. The arm ends in a set of cameras and manipulators/grippers of varying sizes, from large claws to tiny micromanipulators. It also carries a toolkit, which can be customized for a particular task. A grappling arm takes up two tonnes of space and costs 1MCr.

Heavy Grappling Arm

A larger version of the grappling arm, the heavy grappling arm is designed for heavy-duty work. Objects of up to 10 tonnes can be manipulated, and multiple grappling arms can be combined to manipulate larger objects. A heavy grappling arm requires 6 tonnes and costs 3MCr.

External Components Table

Component	Tonnes Requirement	Cost (MCr)
Aerofins	5% hull tonnage	0.1/dT
Docking Clamp	See Docking Clamp Tonnage Table	
Grappling Arm	2	1
Heavy Grappling Arm	6	3



4. Armament

Weapons for spacecraft fall into several basic categories.

- Point Defense nodes
- Turret and Barbette weapons
- Bay weapons
- Spinal mounts

The number of turrets, barbettes or bays that may be installed is limited by the tonnage of the spacecraft. A ship has one hardpoint per 100 tonnes of ship and each weapon system will use one hardpoint. A weapon system may include multiple weapons – for example, a triple turret might contain three lasers, missile launchers, sandcasters or some combination of three weapons.

Point Defense Nodes

Though using turret lasers as point defense can be an effective measure, all vessels may mount point defense weapons that are used as medium to close range anti-missile/torpedo defense. A ship can mount one PD node per hard point in a pop-up micro turret. PD weapons can also act as an anti-intruder defense, in space and on the ground.

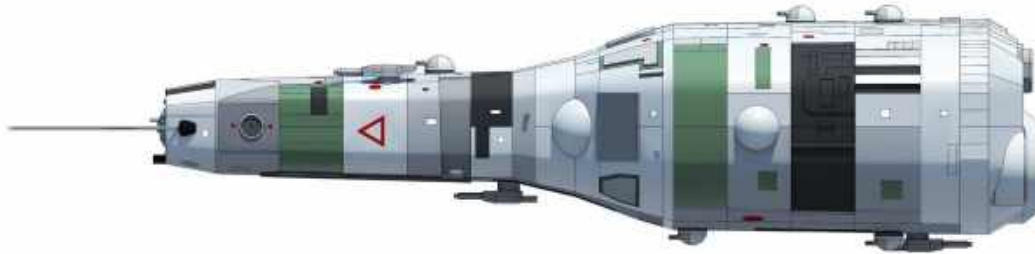
Unlike a laser turret used in a point defense role, PD weapons are automatic and do not require a gunner's interaction. Point defense software must be installed to allow the nodes to operate autonomously to defend the ship. More expensive and more capable PD software is available at higher

tech levels, which can also provide additional DMs to hit. The software follows the same rules as a turret laser firing on a missile, using its rating as a gunnery skill modifier, which will stack with the PD node weapon's bonus. A PD node array is activated by the ship's gunner as required.

PD node weapons are not starship armament and do not require tonnage allocation, though they must be noted on the design. The table below lists the various PD node weapons options and costs while the node pop-up turret itself costs 1MCr

Point Defense System	Bonus	Range	Damage*	Shots	TL	Cost (MCr)
Minigun	0	Close	3D6	100	6	0.3
PD Laser	1	Medium	4D6	n/a	10	0.5
PD Gatling Laser	2	Short	4d6	n/a	12	1
PD VRF Gauss Gun	1	Short	5d6	1000	12	0.75

*Damage is non-ship damage. PD weapons cannot damage ships, only missiles, torpedoes, personnel and vehicles.



Turrets

Turrets are small gun emplacements on the outer hull of the ship capable of independently targeting and tracking enemy ships.

One turret may be attached to each hardpoint on the ship. If a turret is installed, then space must be allocated for the turret fire control system (included in the following table):

Weapon	TL	Tonnes	Cost (MCr)
Single Turret	7	1	0.2
Double Turret	8	1	0.5
Triple Turret	9	1	1
Quad Turret	12	1	2
Pop-Up Turret	10	2	+1
Fixed Mounting	-	0	x0.5
PD Mount	-	0	0.1

Turrets are rated by the number of weapons they can hold. So, a triple turret can hold three weapons, while a single turret can hold only one weapon.

Pop-Up

Pop-Up is a function that can be applied to any type of turret – the turret is concealed in a pod or recess on the hull and is detectable only when deployed. A ship with all its weapons in pop-up turrets looks unarmed to a casual sensor scan.

Fixed Mounting

Fixed Mounting weapons cannot move, are limited to firing in one direction (normally straight ahead) and are found mainly on fighters and other small craft. A fixed mounting costs half as much as a turret of the same type, so a single fixed mounting costs 0.1MCr, a double fixed mounting costs 0.25MCr, a triple fixed mounting costs 0.5MCr and a quad fixed mounting costs 1MCr.



Turret Weapons

Weapon	TL	Optimum Range	Damage	Cost (MCr)
Missile Rack	6	Special	Depends on Missile	0.75
Pulse Laser	7	Short	1d6	0.5
Beam Laser	7	Medium	2d6	1
Mining Laser	7	Adjacent	2d6	0.5
Sandcaster	7	Special	Special	0.25
Particle Beam	8	Long	3d6 + crew hit	4
Railgun	9	Special	Special	1.25
Plasma Gun	11	Medium	2d6+4	2.8

Lasers

- Pulse lasers fire short bursts of energy at targets and have a DM -2 to hit.
- Beam lasers fire continuous beams of energy at targets.

- Mining Lasers are more tool than weapon, used by belters for mining asteroids and salvagers for cutting into ship hulls. At a pinch, though a mining laser makes for a very short range but powerful weapon, though with a -4 DM to an attack roll.

Missile Racks

Missile racks are launchers for small anti-ship missiles. The damage of a missile depends on the type of missile used. Missile racks need ammunition with a twelve-missile pack taking up one tonne of space.

Missiles are capable of thrust 15 but have a limited endurance of 60 minutes (10 turns) before they run out of fuel.

Range	Turns to Impact
Adjacent	-
Close	-
Short	1
Medium	1
Long	2
Very Long	5
Distant	8

Missile Types			
Missile Type	TL	Damage	Cost per 12 missiles (Cr)
Basic	6	1d6	15,000
Nuclear	6	3d6 + crew hit	45,000
Ortillery	7	4d6	25,000
Shockwave	7	special	35,000
Smart (standard military)	8	3d6	30,000
Decoy	9	2d6	35,000
Fragmentation	9	2d6	20,000
Long Range	10	2d6-2	35,000
Multi-Warhead	10	2d6 x 1d6	60,000

Missile Types

Basic missiles

Basic missiles get to make a single attack. This type of missile is freely available to civilian vessels to use for defense. Basic missiles are a sensor guided missile controlled by the ship's fire control and are considerably cheaper and much less accurate than the more sophisticated standard military missile incurring a -4DM over at distances greater than Long range.

Decoy Missile

Armed with a single warhead smaller than those on a standard military missile, decoy missiles also have a pair of small pods equipped with powerful transmitters and jammers. The pods are pre-programmed to detach from the missile before impact confusing point defense systems. All anti-missile fire directed at this missile suffers -2DM.

Fragmentation Missile

Designed to defend a vessel against small craft such as fighters or even clusters of incoming missiles, the fragmentation missile can actively seek incoming fighters or fighter formations exploding just prior to interception sending out a cone of high velocity shrapnel. Especially effective when fired in mass barrages, fragmentation missiles are capable of crippling attacking bombers formations or dispersing fighter screens. Upon reaching a target, the missile will make an attack roll against that target and up to three others within Adjacent range.

Long Range Missile (LRM)

Long range missiles have a smaller warhead to allow them to carry larger engines and travel faster. The long-range missile range table is below.

Range	Turns to Impact
Adjacent	-
Close	-
Short	1
Medium	1
Long	1
Very Long	2
Distant	3

A LRM only deals 2d6-2 damage instead of 2d6, travels at thrust 17, costs 35,000Cr and has an endurance of 7 turns.

Multi-warhead Missile (MWM)

Multi-warhead missiles carry a payload of six warheads. The downside is that the larger payload slows the missile, so it takes longer to reach its target.

Range	Turns to Impact
Adjacent	-
Close	-
Short	1
Medium	1
Long	2
Very Long	3
Distant	6

An MWM that hits its target deals 2d6 damage 1d6 times, travels at thrust 10, costs 40,000Cr and has an endurance of 10 turns.

Nuclear missiles

Nuclear missiles make a single attack as basic missiles but also inflict a radiation crew hit as well as a normal hit. Civilian ownership of nuclear weapons is strictly prohibited by various long-standing agreements by all civilized nations and independent planetary systems, agreements that pre-date any settlement in Clement Sector.

Ortillery Missile

Ortillery missiles are specially designed for planetary bombardment. They are too slow to be used as anti-ship weapons except at Close or Adjacent range. Attacks made with an Ortillery Missile have a -2DM to hit and Point Defense attacks against the torpedo have a +2DM.

Shockwave Missile

These missiles carry a special magnetic-pulse warhead. The blast is harmless to spacecraft, but it scatters and polarizes sand clouds, making them useless. A ship struck by a shockwave missile cannot use sand for the rest of the turn that the shockwave missile has made a successful attack.





Smart (standard military) missiles

Smart missiles may keep making attacks until they hit or are destroyed. This type of missile is used by naval vessels, and civilian vessel owners or captains will be prosecuted if they are found to be using them.

Particle Beams

Particle weapons fire a stream of accelerated subatomic particles. They inflict an automatic radiation crew hit in addition to any other damage. Only one particle beam weapon can be mounted in a turret; however, this must be a triple turret due to the bigger size of the weapon.

Plasma Guns

Plasma guns are a less powerful version of the much larger barbette mount. Fed directly by the ship's fusion power plant, these weapons fire bolts of star hot plasma at their target causing thermal and kinetic damage if a hit is successful.

A plasma gun can be mounted singly within a double turret, a pair in a triple turret or three in a quad turret. The weapons power feeds and cooling equipment required will use the space provided by the remaining vacant mount within the turret.

Plasma guns are not available for use on civilian space vessels.

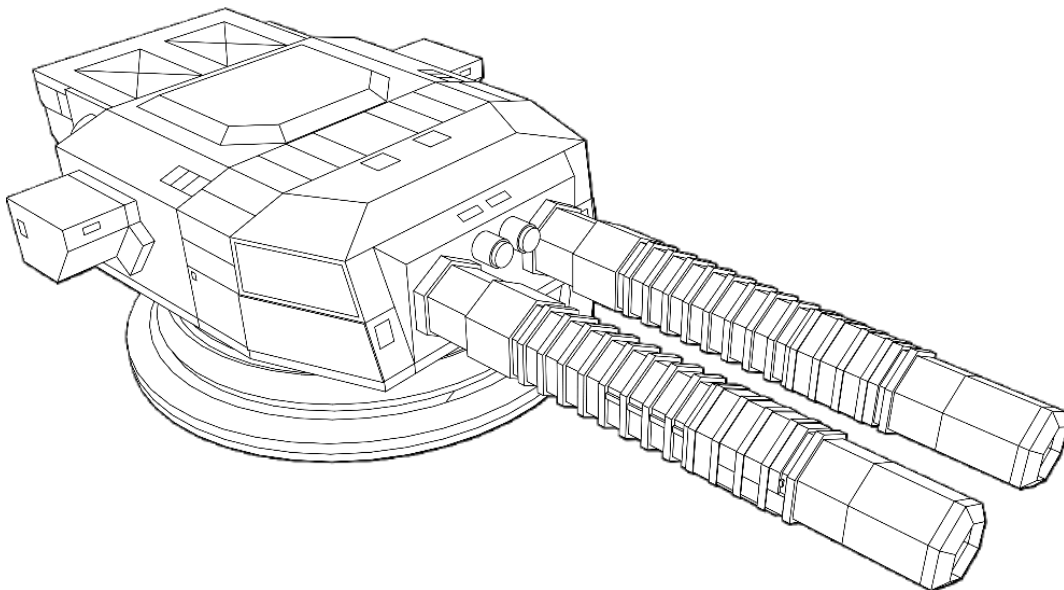
Railguns

A less powerful version of the much larger barbette mount, turret mount railguns are rapid-fire short-range weapons using a coil of electromagnets to accelerate ferrous projectiles to great speed. Apart from being able to be used with great effect as an offensive weapon, railguns are also superb point defense weapons.

Turret mount railguns can also be fired in five round bursts causing an additional 3 points of damage per successful hit. See railgun barbette mounts on page 426 for more details regarding projectile types.

<i>Railgun Projectile Types</i>				
Projectile Type	TL	Damage*	Number of projectiles/dT	Cost per reload (Cr)
Basic Kinetic Kill	9	1d6	30	5,000
Canister	9	1d6+2	20	8,000
Penetrator	10	2d6	15	15,000

* For five round burst fire +3 damage



Sandcasters

Sandcasters are primarily anti-laser defensive weapons; they dispense small particles which counteract the strength of lasers and protect the ship. A sandcaster reduces the damage from a beam weapon by 1d6. They are remarkably flexible weapons and are capable of carrying different payloads. Sandcasters require ammunition.

Sandcasters are as effective as lasers used for point defense as long as the missile it is defending against is fired from at least medium range.

Twenty standard sandcaster barrels or canisters take up 1dT of space, and cost 10,000 Cr.

<i>Canister Types</i>			
Canister Type	TL	Damage	Cost per 20 canisters (MCr)
Pebbles	7	1d3 ¹	0.20
Sand	7	-	0.01
Chaff	8	-	0.25
Sandcutter	8	-	0.35

¹ See Pebbles description below.

Sandcaster Canister Types

Chaff

A Sandcaster chaff canister disrupts sensors and communications within the chaff cloud. All Comms, Sensors, Remote Operations, or missile attack rolls within a chaff cloud suffer a -1 DM and can be fired at any target within Close range. They do not provide protection against laser fire.

Pebbles

Pebble canisters are designed as basic offensive rounds for a sandcaster. Pebble round canisters allow the sandcaster to deal 1d3 kinetic energy damage instead of one damage when used as an attack. They do not provide protection against laser fire.

Sandcutter

Essentially an anti-sandcaster round, a sandcutter round fires a hail of electromagnets into the midst of an enemy sand cloud. These magnets cause the sand to clump together so reducing effective protection and a successful use of a sandcutter shot halves the protection offered by a sand cloud. Typically, a Sandcutter round will be fired in coordination with a laser beam attack. They do not provide protection against laser fire.

Barbettes

A barbette is essentially a heavy turret, able to mount larger, more powerful weapons or more weapons than a standard turret can mount. A barbette takes up a turret hardpoint, but also uses 5 tonnes of space inside the ship; as the larger weapons mounted in a barbette need room for capacitors, targeting mechanisms, ammo feeds, ready use ammunition and other components. Barbettes require Gunner (Turrets) skill.

Retractable Barbette Turret

A barbette turret can be made retractable allowing it to be protected during atmospheric maneuvering or to be hidden by direct observation and casual scans. The ability to hide a barbette turret allows heavier armament to be installed on Q-ships providing a nasty surprise for any attacking vessel thinking the target is lightly armed and then facing a ship with a more powerful barbette weapon. Turret retraction equipment adds 2dT and an additional cost of 3MCr.

Barbette Weapons								
Weapon	TL	Optimum Range	Shots per Round	Damage	Cost (MCr)	Internal Ammo Loadout	Ammo	Ammo Cost per dT (Cr)
Missile	7	Special	1	By Missile	4	24	12/dT	Special
Mine Launcher	8	Special		By Mine	2	6	6/dT	Special
Particle Beam	8	Long	1	4d6	8	-	-	-
Railgun	9	Short	1	By Projectile	4	By Projectile Type	20/dT	Special
Torpedo	9	Special	1	By Torpedo	3	2	2/5dT	Special
Plasma	11	Medium	1	4d6	5	-	-	-
X-ray Laser	11	Medium	1	3d6+1 + crew hit	3	-	-	-

Missile

Capable of firing six missile salvos, the missile barbette has fallen out of favor with the introduction of more capable multiple mount turret types.

Railguns

Railguns are huge gauss weapons, using a coil of electromagnets to accelerate ferrous projectiles to great speed. Railguns are not as effective in starship combat as directed energy weapons and missiles, but do have some tactical advantages, as it is very difficult for a ship's point defense weapons to counter an incoming very high velocity metal projectile. Railguns are superb heavy point defense weapons and railgun armed escort vessels such as Australia's *Perth*-class frigates are considered highly effective combat proven vessels. Railguns can only be used at short range or less.

A railgun barbette takes up five tonnes of space and includes space for a one tonne reload of projectiles.

Railgun ammunition types are listed in the table below.

Railgun Projectile Types				
Projectile Type	TL	Damage	Number of projectiles/dT	Cost per reload (Cr)
Basic Kinetic Kill	9	3d6	16	5000
Canister	9	3d6	16	8,000
Penetrator	10	4d6	12	15,000

Railgun Projectiles

Basic

A kinetic kill weapon, the basic rail gun projectile is a solid metal dart that relies on kinetic energy to damage the intended target. These are often used to attack orbital defenses and other targets on predictable trajectories.

Canister

Used for point defense, the canister projectile comes apart at a pre-determined distance from the firing ship sending thousands of balls at very high velocity directly into the path of incoming missiles, torpedoes, fighters, or assault craft.

Penetrator

A solid crystaliron core sheathed in hardened alloy, the penetrator is designed to penetrate thick hull armor or into facilities deeply buried in asteroids. The very high kinetic impact energy causes heavy damage to the intended target. Penetrators are larger than the size of other rail gun projectiles, but only slightly less slow.

Mine Launcher

Mine launchers are used to deploy mines into space, at either Zimm points or other strategic locations. The use of mines is prohibited by various long-standing agreements by all civilized nations and independent planetary systems, agreements that pre-date any settlement in Clement Sector but that does not stop less scrupulous planetary governments or organizations from using them. A mine dispenser holds six mines.

A very simple device, a mine is made up of a warhead, processor, and an ion thruster pack. They are deployed in a small area where they remain dormant until a suitable target is detected. Once this is the case they will activate their thrusters and maneuver into contact or proximity, before exploding. A nuclear mine will do an automatic radiation crew hit in addition to damage listed.

Mines are pre-configured with a given set of perimeters defining a viable target before being deployed. This might be a particular transponder signal, lack of a particular transponder signal or lack of correct IFF. They can also be set to attack a target over a given tonnage, within a tonnage range or detonate after a time delay once a target has been verified, to trap more targeted vessels within the field. A mine will attack target ships when they move to within Adjacent or Close range.

Mines are treated like any weapon system requiring ammunition. There are six mines in 1 tonne.

Mine Type	Mine Types		
	TL	Damage	Cost per reload (MCr)
Nuclear	8	4d6	0.25
Standard	8	3d6	0.02
Bomb-Pumped Laser	9	5d6	0.75

Deployable Mine types

Bomb-Pumped Laser

The most powerful mine available for deployment, the bomb pumped laser mine contains a small nuclear device that is detonated prior to impact to charge a laser generating a powerful x-ray laser burst. The bomb-pumped laser is a normal laser attack but deals 5d6 damage. If the target has deployed sand prior to the mine attacking, then it can be defended against as a laser.

Nuclear

Containing a small nuclear warhead with a proximity fuse a nuclear mine deals 4d6 damage, as well as an automatic radiation crew hit unless the target has an active magnetogravitic screen. See page 87 for more information about magnetogravitic screens.

Standard

The standard mine contains a high explosive warhead with a proximity fuse and can deal 3d6 damage to a target.

Torpedoes

Considered true ship killers with the ability to inflict tremendous destructive force against an enemy combatant, torpedoes are heavy 2.5dT anti-ship missiles with a thrust of 12. Like smart missiles, they can be defended against using standard anti-missile countermeasures. Torpedoes are purchased in two-shot loads of five tonnes each.

Except for the ortillery version, torpedoes cannot be used in atmosphere.

Torpedo Type	Torpedo Types		
	TL	Damage	Cost per Torpedo (MCr)
Basic	7	4d6	0.05
Nuclear	7	6d6 + crew hit	0.18
Ortillery	8	8d6	0.12
Bomb Pumped	9	7d6	0.2
Multi Warhead	10	4d6	0.1
MW Nuclear	10	5d6 + crew hit	1.2
MW Bomb Pumped	11	6d6+1	2.2

Torpedo Types

Basic

Effectively a kinetic kill weapon, the basic torpedo consists of a small but powerful engine, guidance computers, and a fragmentation device. It deals 4d6 damage on a successful hit.

Nuclear

A nuclear torpedo will deal 6d6 damage, as well as an automatic radiation crew hit.

Bomb-Pumped Laser

The primary anti-ship torpedo, the bomb-pumped laser torpedo is a one-shot laser weapon. The torpedo contains a small nuclear device that is detonated prior to impact to charge a laser. The explosion destroys the torpedo, but also generates a powerful x-ray laser burst. The bomb-pumped laser is a normal laser attack but deals 7d6 damage. The basic roll to hit is as a missile but is defended against as a laser. Point defense can be used to attempt to kill the torpedo before it detonates but suffers a -2DM due to the fact the bomb-pumped laser can be used in a standoff role.

Ortillery

Heavy ortillery torpedoes are used for bombing fortified positions. They deal 8d6 damage but are much too slow to be effective in space combat. They move at the same speed as a multi-warhead missile. Attacks made with an Ortillery Torpedo have a -2DM to hit and Point Defense attacks against the torpedo have a +2DM.

Multi Warhead

Payload consists of four warheads that after separation can perform limited independent avoidance maneuvering using the torpedoes terminal acceleration. Because of the multi-warhead design, the *MWT* is less damaging per warhead than a single warhead torpedo against an enemy combatant. Overall, though, with four warheads per torpedo, the damage inflicted to an enemy target, if more than one warhead strikes, is significantly higher. The *MWT* has a maximum thrust of 12G.

For determining missile barrage attacks refer to Module 5 - Advanced Space Combat. Each warhead is to be considered an incoming threat.

For example, if a full 6 torpedo salvo of a multi-warhead torpedo is fired from a one-hundred-tonne torpedo bay then it will have a barrage number of 30 (6 x 4 = 24).

X-ray Laser

Bomb pumped laser warheads, for both mines and torpedoes, have been in use as weapons for well over one hundred years. However, non-destructive generation and directing a created x-ray beam has always been quite problematic. Essentially, a directed x-ray laser weapon requires the detonation of a small nuclear charge within the ship itself and then directing that energy through the laser emitter without destroying everything around it – including the firing ship.

X-ray lasers are more powerful than standard beam lasers, have less range, and will cause a radiation hit to the targeted ship's crew.



Bays

Bay weapons are much larger than turrets and are able to mount larger weapons or multiple smaller weapons. Bays are 50 tonnes (Light Bay) or 100 tonnes (Medium Bay), use one hardpoint and 1dT of fire control. Bays are found only on larger naval vessels and capital ships.

All bay weapons suffer a -2DM when attacking targets from 200 to 1000 tonnes and a -4DM when attacking targets of 100 tonnes or less. The exception to this is railgun bays firing canister projectiles.

Heavy Bays

Available at TL11, the 500-tonne heavy bay provides a larger warship with a significant increase in firepower and is only available to be installed on naval capital ships such as cruisers or monitors. A heavy bay uses five hardpoints, 1dT of fire control, and can only mount energy weapons or railguns. However, the use of such large bays are debated by naval authorities as only the largest warships can effectively utilize them, however there are a number of naval designs using the heavy bay as a mini spinal mount.

A heavy bay has a +4DM when attacking targets of over 3000 tonnes due to the much greater amount of weaponry they hold. While these bays are effective at engaging much larger targets, they do have issues when engaging lighter combatants, suffering a -2DM when attacking targets from 200 to 1000 tonnes and a -4DM when attacking targets of 100 tonnes or less. The exception to this is railgun bays firing canister projectiles.

Like smaller bays, the number of heavy bays that a capital ship can mount is limited by the ship's power plant (see power plant section on page 35) and by the number of hardpoints.

Because of their large size and high-power requirements, heavy bays require a minimum power plant rating of 3 and can only be installed once per 1000 tonnes. Total number of bays then available to be installed per 1000 tonnes is reduced by 3.

For example, a naval architect intending to install a power plant with a rating of 5 as part of a heavy cruiser design can elect to install five standard bays or one 500-tonne heavy bay and one standard bay per 1000 tonnes of hull.

Bays on Capital Ships

The number of bays that a capital ship can mount is limited by the ship's power plant (see power plant section on page 35) and by the number of hardpoints.

Bay on Non-Capital Ships

Standard spacecraft can carry bays with the maximum number limited by hull displacement/1000, multiplied by the power plant rating number (rounded down, but not less than one). Small craft can only carry one bay. A Heavy Bay cannot be installed on a non-Capital ship.

For example, a 2,000dt ship with a type N power plant (rating of 2) would be able to support a maximum of 4 bays.

Bay Weapons				
Weapon	TL	Range	Damage	Cost (MCr)
50 Tonne		Light Bay		
Missile	6	Special	Flight of 12 missiles	12
Particle Beam	8	Long	6d6 + crew hit	20
Torpedo	9	Special	Flight of 3 torpedoes	12
Fusion Gun	12	Medium	5d6	8
Meson Gun	11	Long	5d6 + crew hit	50
Rail Gun	9	Short	3d6 x 2	30
100 Tonne		Medium Bay		
Missile	6	Special	Flight of 24 missiles	24
Particle Beam	8	Long	9d6 + crew hit	40
Torpedo	9	Special	Flight of 6 torpedoes	24
Fusion Gun	12	Medium	8d6	16
Meson Gun	11	Long	8d6 + crew hit	100
Rail Gun	9	Short	3d6 x 4	60
500 Tonne		Heavy Bay		
Particle Beam	8	Long	12d6+4 + crew hit	100
Fusion Gun	12	Medium	11d6+4	130
Meson Gun	11	Long	11d6+4 + crew hit	220
Rail Gun	9	Medium	3d6+2 x 6	90

Bay Weapon Types

Missiles

Taking advantage of a bays increased size, a missile bay can unleash much larger salvos of missiles at a target, overwhelming its active point defenses. For any given round, a 50-tonne small bay fires 12 missiles at a time and a 100-tonne medium bay fires 24 missiles. Each bay holds enough missiles for 12 full salvos. In per missile terms this equates to 144 missiles in a small bay and 288 missiles in a medium bay.

Torpedoes

A 50-tonne torpedo bay fires three torpedoes per salvo while a 100-tonne torpedo bay fires six torpedoes per salvo, however a bay can fire a single torpedo rather than a full salvo if required. Apart from bigger torpedo salvos, a torpedo bay performs as a standard torpedo barbette. Each bay holds enough torpedoes for 2 full salvos. So, 6 and 12 torpedoes respectively. For more sustained salvo fire, a magazine adjacent to the bay must be considered.

Railgun

Railgun bays consist of multiple linked railguns firing on full auto. A fifty-tonne bay fires bursts of eight projectiles and the 100-tonne bay bursts of twelve dealing 3d6 (x multiplier) damage on each successful burst hit. A fifty-tonne bay has internal capacity for 200 projectiles and the one-hundred-tonne bay, 400 projectiles.

Heavy Railgun

The heavy version of the railgun bay can fire bursts of fourteen projectiles dealing 3d6+2 (x multiplier) damage on each successful burst hit and includes space for 600 projectiles.

Ortillery Railgun

This variation on the standard 50-tonne railgun bay is also known as a mass driver. It fires larger projectiles at slower speeds that are optimized for smashing planetary targets. The bay includes space for 10 shots of ammunition. A single hit from an ortillery railgun is like a tactical nuclear strike, but attacks against mobile ground targets with an ortillery railgun suffer a -4 DM. Each tonne of ortillery railgun contains two shots costing 5000Cr. An ortillery railgun bay is a specialized version of the light and medium railgun bays but costs the same.

Heavy Ortillery Railgun

This mass driver railgun heavy bay fires larger projectiles at slower speeds that are optimized for smashing planetary targets. Much bigger again than 100-tonne mass driver bays, a typical mass driver heavy bay projectile displaces twenty tonnes and cost 200,000Cr each. The bay includes space for 10 projectiles each of which cost 2500Cr. A heavy ortillery railgun bay is a specialized version of the heavy railgun bay but costs the same.

Particle beam

Particle beams are larger versions of the turret and barbette mounted weapon.

Fusion gun

Fusion guns fire a directed beam of fusing hydrogen at targets.

Meson gun

Using dual particle accelerator technology, meson guns fire destructive beams that ignore all types of physical armor, producing intense radiation effects inside a target. Mesons have an extremely short half-life and are calculated to decay while within the enemy ship. Meson weapons are therefore unaffected by physical armor, as the blast only becomes harmful after it has already passed through the hull. Meson guns inflict an automatic radiation hit on the crew of any target struck in addition to normal damage. Meson guns are defended against by hull radiation shielding or magnetogravitic screens.

Ordnance Magazines

Standard

All barbettes and bays require adjacent allocated space if the weapons mounted require any reloads beyond what is loaded within the hardpoint mount. A turret-mounted weapon requiring ordnance must have at least a one-tonne magazine per weapon type installed. Magazines link to the hardpoint via autoloader feeds that automatically reload once the ammunition inside the hardpoint mount is used. Civilian ships will almost never allocate more than the minimum magazine space required for additional reloads due to the impact on cargo and passenger space.

Improved

The improved magazine provides better protection if installed instead of a standard magazine, providing an additional hit negation if installed alongside armored bulkheads or one hit negation (as per armored bulkheads) if armored bulkheads are not installed. Improved ammunition magazines cost 0.1Mcr per allocated tonne.

Spinal Weapons

Spinal weapons are huge particle or meson weapons that run down the axial length of only the very largest capital class spacecraft. A single shot from a spinal weapon can cut a lesser vessel in two. Only the very largest in-system monitors, such as those in service with the Hub Federation and the Monroe System Defense Force are armed with spinal weapons.

Meson Gun and Particle Beam

The damage of a spinal weapon depends on the size and type of weapon. On the table below, spinal weapon damage is measured in capital ship damage terms but for damage to non-capital

spacecraft, the damage is the barrage value in d6. Spinal mounts use a number of hardpoints equivalent to their tonnage divided by 100. All weapons have long range. A ship may only have one spinal mount.

Particle					Meson				
Type	TL	Tonnes	Damage	Cost (MCr)	Type	TL	Tonnes	Damage	Cost (MCr)
A	8	5000	200	3500	A	11	5000	200	5000
B	12	3500	300	2100	B	11	8000	250	8000
C	10	5000	300	3500	C	12	10,000	350	10,000
E	12	4000	400	2800					

Increasing Tech Level will reduce spinal weapon size and cost and provide some improvement in performance.

Type	TL+1	TL+2	TL+3	TL+4
Particle				
Size and Cost	-10%	-20%	-30%	-40%
Damage	+5%	+10%	+15%	+20%
Meson				
Size and Cost	-20%			
Damage	+10%			

Meson Gun Spinal Mount Penetration is graded on the amount of damage they inflict in accordance with the following table:

Damage	Penetration
200 - 259	I
260 - 309	II
310 - 359	III
360 - 400	IV

Railguns

Eschewing multiple rapid firing guns, the railgun spinal mount fires far larger rounds at near relativistic speeds that smash through reinforced armor and cause extensive damage to internal components. Five 20-tonne rounds are included within the railgun tonnage. Additional rounds cost 0.2MCr each.

Railgun				
Type	TL	Tonnes	Damage	Cost (MCr)
A	9	4000	130	3000
B	10	5000	250	3500
C	11	4500	300	4900

Increasing Tech Level will reduce spinal weapon size and cost significantly along with some improvement in performance.

Railgun	TL+1	TL+2	TL+3	TL+4
Size and Cost	-10%	-20%	-40%	-50%
Damage	+5%	+10%	+20%	+30%

Railgun spinal mounts are less effective at hitting independently maneuvering targets at longer ranges than meson or particle spinal mounts, due to the sublight speed of the projectile. However, for targets that are in predictable trajectories) or non-moving ground targets such as fortifications) they are exceedingly effective.

Any mobile target over medium range suffers a -1 DM to achieve a hit and if that target is over long range that penalty increases to -2 DM. Any small target to-hit penalties also apply.

For a stationary or predictable path target (such as orbital facilities), there is a +1 DM over medium range. Predictable path targets can have their trajectories or course analyzed by the firing vessel with a high degree of accuracy and the projectile fired to intercept the target.

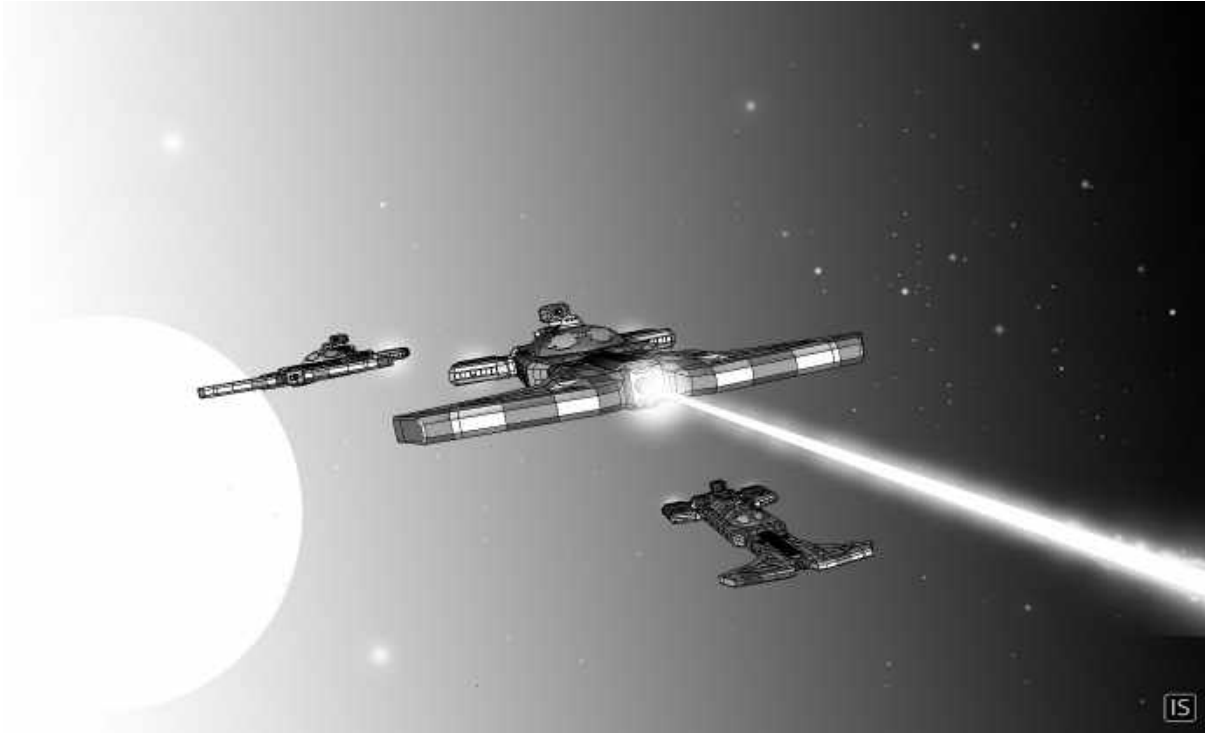
Railgun Spinal Mount Penetration is graded on the amount of damage they inflict in accordance with the following table:

Damage	Penetration
100-199	I
200-299	II
300-399	III
400+	IV

Railgun spinal mounts ignore armor equal to three times its penetration rating (see penetration table above) with any residual armor reducing the damage inflicted on a successful hit by twenty times per point of armor remaining.

Rapid Fire

A rapid-fire spinal weapon is equipped with capacitors and redundant reaction chambers. It can be fired twice in a round instead of once, but only if it does not fire at all in the following round while the capacitors recharge. Making a spinal weapon to be rapid fire increases the tonnage and the cost of the weapon by 15%.



Screens

Magnetogravitic

A breakthrough development that expands and greatly strengthens the relatively weak gravitic field generated by a ship's drive, the Magnetogravitic (MaGG) screen is being seriously considered for inclusion in new warship construction by major naval forces. The current refit of the Hub Federation Navy *Moltke*-class cruisers and the new build *Australia*-class cruisers of the New Perth Navy for example, includes this new technology.

The MaGG screen provides defense by blocking passage of high-energy particles from particle beams, meson guns, fusion guns and nuclear weapons (single warhead or salvo). Installation of a single screen generator reduces damage from such weapons by 2d6. Each generator added creates an additional screen layer with each layer providing a further 1d6 damage reduction. A MaGG screen will remove radiation damage to the crew automatically. A radiation shield and MaGG screen cannot be installed together.

A warship with the screen active can "flicker" the screen whilst firing its own particle beams, meson guns and fusion guns much like the interrupter gear mounted on the first atmospheric fighters.

Because a MaGG screen interferes with the creation of a Zimm bubble it must be powered down before a ship can use its Zimm Drive. MaGG screens can be used within gravity wells and close orbit but cannot be used within atmospheres. Additionally, any sensor scan using densitometers made against a ship with an active screen will fail.

Screens are not available for civilian use. Only navy vessels will be so equipped.

Hull Code	TL	Tonnes	MCr
A to CE	12	30	60
CF to CK	12	40	80



Design example – The Main Compartment – Armament

A 200 tonne hull allows for two available hard points and two PD nodes. To keep purchase costs down, only one hardpoint will be fitted with a triple turret and only the fire control allocated for the other. No PD node mounts will be installed. A space of 2dT is allocated for reloads.

Providing a mix of weapons for the single triple turret allows for a layered defense.

Fire control for empty hardpoint = 1 x 1dT = 1dT

Triple Turret = 1dT (with fire control included) costing 1MCr.

Magazine for both missile and sandcasters = 2dT

Weapons in turret:

1 x beam laser = 1MCr. 1 x Missile Rack = 0.75Mcr 1 x Sandcaster = 0.25Mcr = 2MCr.

Main Compartment – Armament: Allocation = 4dT, Cost = 3MCr.

5. Small Craft, Vehicles, Drones, and Cargo Holds

Spacecraft can carry several small craft, vehicles and drones depending on the spacecraft's size and intended role. These Small Craft are either docked within a hangar or attached externally, while vehicles tend to be stored within vehicle bays. During design, any allocation made for any small craft or vehicles must indicate if that small craft or vehicle is to be carried either on the outer hull or in a hangar on board. Drones will have their own allocations depending on type.

Boarding Pod

A variation of the 10-tonne transfer launch, the boarding pod carries up to six boarders and uses a breaching tube to quickly cut through the outer and inner hulls of the vessel being boarded. The boarding pod is capable of 6G thrust for a short period (up to ten turns or sixty minutes) to rapidly close on a target vessel that may be still maintaining a high level of acceleration itself.

Because of their expense and specific purpose, boarding pods are not used by most modern naval forces. However, boarding pods are often still used by Special Forces units such as the Hub Federation Marine Commando and by some pirates who believe the terror factor of multiple boarding pods cutting through the hull of a helpless targeted ship outweighs their tactical inflexibility.

A boarding pod costs 12.5MCr and requires a pilot.

Escape Pod

Escape pods can be provided for the use of both crew and passengers in the case of emergencies requiring the need to abandon the ship. A standard escape pod is for a single person while a standard double occupant escape pod is simply a larger version of the single occupant type.

An escape pod is a large, pressurized plastic spherical bubble 2m in diameter. Piezoelectric layers within the bubbles inner wall convert the occupant's movements into power to recharge the bubble's batteries and power its distress beacon. An oxygen tank both inflates the bubble and provides eight hours of life support. A self-repairing plastic seal serves as an emergency airlock.

Ship's Launch, Ship's Boat, Pinnace, Cutter and Shuttles

These are all small craft docked within internal hangars or attached to the outside hull of the ship. Data for these and other small craft can be found in *Independence Games' Ships of Clement Sector 4-6: Traders, Scouts and Small Craft*.

Grav and Ground Vehicles

These are vehicles, usually stored in a standard vehicle hangar inside the vessel. Costs and data for these and other vehicles can be found in *Independence Games' 21 Vehicles*.

Mining Drones

Belters use mining drones to mine asteroids. Each set of mining drones requires an allocation of 10dT and allows the ship to process 1d6 x 10dT of asteroid materials per working day. Included within the tonnage allocated is the ore handling machinery, which allows the ship to take on ore and transfer it to the cargo hold.

Point Defense Drones (PDD)

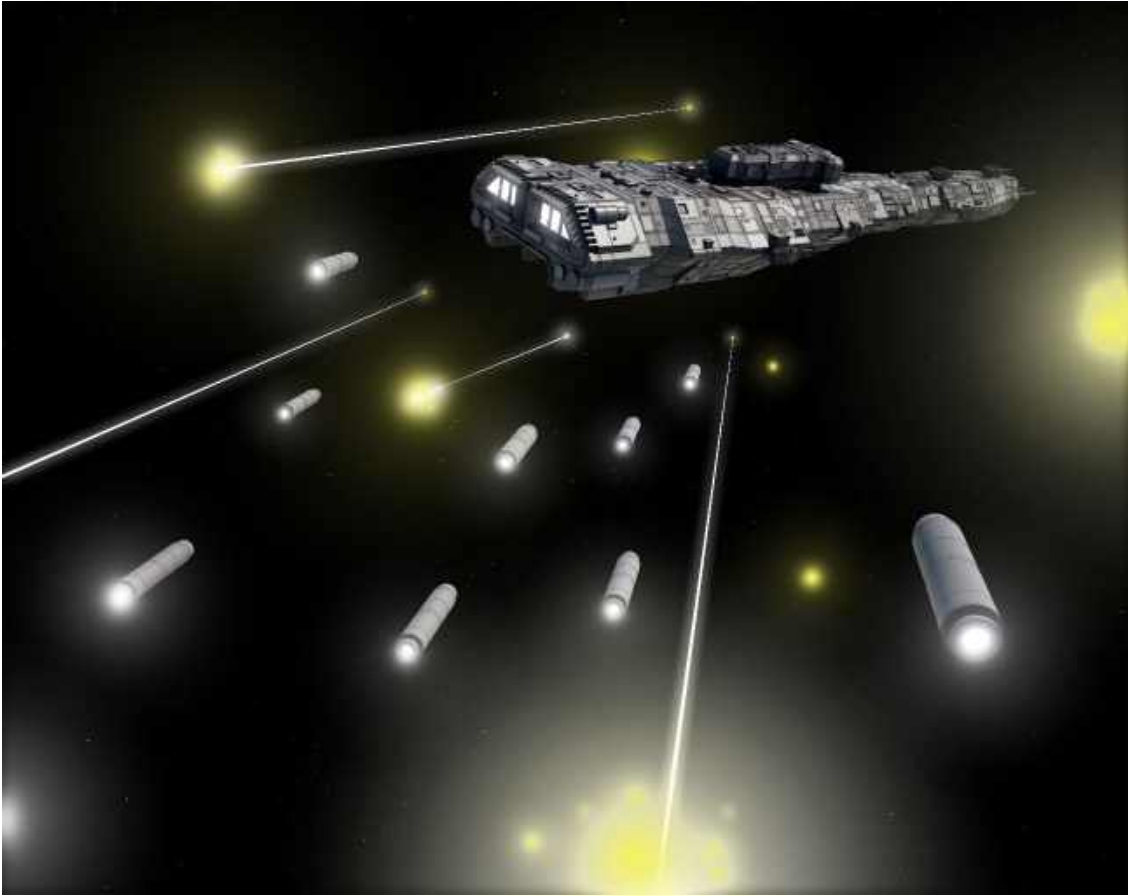
A small-armed drone designed to create or extend a ship's point defense sphere beyond the normal ranges of PD node weapons, a PDD is armed with the same type of weapons and magazine load out as standard PD nodes.

Point defense drones are available in packages of five with cost being fifty times the cost of the PD Node weapon type. Thruster packs allow the drones to maintain the same thrust and direction as the parent vessel and allow the drones to be repositioned as required. PDDs are optimized to provide interlocking defensive fire between short and medium range but can be deployed at close range if necessary. PD node weapon types can be found on page 66.

For effective coverage, the number of drones that required for deployment is determined by the available number of PD nodes for the vessel hull size. PDDs cannot be used by vessels under 500 tonnes. PDDs have enough power for 60 minutes (10 turns) after which they run out of power and cannot accelerate, maneuver, or fire their weapon.

Additional point defense software is required for PDD operation. The software package provides the same modifiers as standard point defense node software, as well as interactively coordinating defensive fire with the ship mounted PD node array.

The launcher for the drones is identical to that of a probe drone, requiring 1dT of space at a cost of 0.5MCr. There are 5 drones per tonne.



Probe Drones

Probe drones are used for surveying planetary surfaces, surveying orbiting satellites, derelicts and other space debris and act as communication relays. When surveying planetary surfaces, a probe drone is launched from orbit in disposable entry shells and must be recovered manually after mission end. There are 5 probe drones per 1dT allocation. See page 340 of *Clement Sector* for probe drone data.

Re-entry Capsule

Available since before the discovery of the Zimm Drive, TL 8 Re-entry capsules allow occupants of a spacecraft to quickly exit and descend to the surface of any planet it is orbiting. Featuring heavy heat shielding they can provide a rocky, though relatively safe, descent through the atmosphere. Each capsule holds a single person and is generally used as an emergency escape facility to save lives when a ship is in danger of being destroyed. Each installed re-entry capsule requires 0.5 tonnes and costs 20,000Cr.

Re-entry Pod

Larger than a re-entry capsule a TL 9 re-entry pod serves a similar purpose to a capsule but has a gliding surface and computer guidance, this provides the two occupants with more control of

the descent in order to avoid potentially dangerous terrain so to arrive safely to the planet's surface. Full manual control of a descent is available if one of the occupants has the Flyer (wing) skill. Each installed re-entry pod requires 1 tonne and costs 150,000Cr.

Repair Drone

The inclusion of repair drones allows a ship to make general maintenance and urgent battlefield repairs with the AutoRepair software or when managed by a crewmember with Mechanic or Engineer skills. Repair drones have the same statistics as repair robots (See page 339 of *Clement Sector*) but without an Intellect program.

Small Craft, Vehicles and Drones

Vehicle	Tonnes (dT)	Cost (MCr)
Boarding Pod	10	12.5
Escape Pod (double)	1.0 per stateroom	0.2 each
Escape Pod (single)	0.5 per stateroom	0.1 each
Grav & Ground Vehicles	10	0.05
Grav Utility Vehicle (GUV)	4	0.275
Mining Drones	10	1
Point Defense Drones (5)	1	0.5 per tonne
Probe Drones (5)	1	0.5 per tonne
Re-entry Capsule	0.5	0.02 each
Re-entry Pod	0.5	0.15 each
Repair Drones	0.01 tonnage of ship	0.2 per tonne
Small Craft: Ship's Launch	20	14
Small Craft: Ship's Boat	30	16
Small Craft: Pinnace	40	20
Small Craft: Cutter	50	28
Small Craft: Shuttle	95	33

Hangars

Standard

Normally, when a small craft is included in the design of a vessel, it is installed into a form fitting enclosure in the hull of the mother vessel with just enough room for passengers to enter and exit the small craft. Due to the form fitting nature of the standard hangar, almost all repair and maintenance tasks require the small craft to be launched first. A standard hangar requires 110% of the stored craft's tonnage and costs 0.2MCr per dT. Round fractions to the nearest whole tonne.

Full

If space permits, then the preferred option for storage of small craft on military vessels is the full hangar. A full hangar allows for repair and maintenance of small craft when they are back on the ship. The hangar includes storage for spare parts and specialized testing and repair equipment for the stored craft. A hangar requires 130% of the stored craft's tonnage and costs 0.2MCr per dT.

For example, carrying a modular cutter in a standard hangar normally takes up 55 tonnes of space. If the cutter is given a full hangar, then it requires 65 tonnes of space instead.

Hangar Deck

For use when there are multiple small craft required to be stored onboard the spacecraft, the hangar deck requires more interior space to allow small craft (such as fighters) to be stored, maintained, and easily moved within. A Hangar Deck and associated maintenance facilities require 200% of the largest small craft intended to be stored and costs 0.25MCr per dT.

<i>Hangar Types</i>		
Type	Multiplier	Cost (MCr) per dT
Standard	x1.1	0.2
Full	x1.3	0.2
Deck	x2.0	0.25

Launch tubes and Flight decks

To facilitate rapid launching of small craft such as fighters, carriers will often use launch tubes or flight decks to deploy fighters quickly using electromagnetic technology like that used by railguns. Though both the internally mounted launch tube and externally mounted flight deck are similar in function, a launch tube can only launch small craft while the flight deck can both launch and recover small craft. Normal launch and recover operations for a small craft from a larger vessel can take over 30 minutes or five rounds for one craft, however utilizing a launch tube or a flight deck will take only one round to prepare a small craft for launch and a subsequent single combat round to launch it. Both the ship launching the small craft and the small craft itself can expend thrust and make attack rolls during this round. A flight deck or launch tube can only launch one craft at a time. A flight deck can only recover one craft at a time.

For both the launch tube and the flight deck, the length of the launch system allows a small craft to achieve an 8G "push" to accelerate the small craft away from the launching ship. Subsequent maneuvering other than the launch direction reverts the small craft to its own thrust capability.

Launch tubes and flight deck launching and recovering multiple small craft (most notably fighters) simultaneously can be installed on larger vessels with the space to accommodate them.



Launch Tube

The size requirement of a launch tube is five times the tonnage of the largest craft that will be deployed in this manner, costing 1MCr per tonne. The minimum length of the launch tube in meters is four times the tonnage of the small craft intending to be launched. Allocation for a launch tube includes the launch tube, launch machinery and the dispersal area outside the launch tube itself. Additionally, any ship using a launch tube must have a full hangar allocation. This hangar space is usually adjacent to the dispersal area outside the launch tube itself. A launch tube must also be provided a recovery deck to allow small craft to be recovered back into the mothership.

Flight Deck

Combining a launch and recovery system, the external flight deck is connected via small craft lifts to the main hangar deck below. Small craft are raised to the flight deck dispersal area and launched via electromagnetic acceleration rails.

The size requirement of a flight deck is three times the tonnage of the largest craft that will be deployed in this manner, and they cost 0.5MCr per tonne. The minimum length of a flight deck in meters is four times the tonnage of the small craft intending to be launched. Allocation for a flight deck includes the launch/recovery machinery, deck gravity plates and lifts. As the actual flight deck and the dispersal area are external of the ship, no further allocation is required. Additionally, any ship using a flight deck must also have a full hangar allocation. This hangar space is usually below the dispersal area to the rear of the flight deck itself.

Recovery Deck

A recovery deck allows for the rapid recovery of small craft only. For example, allowing a carrier to quickly recover fighters just prior to making a transition or to recover them quickly to re-arm and prepare for re-launch via their hangars or a launch tube. Recovery decks usually include arresting equipment that slows or stops the motion of any small craft that enter it too quickly. Recovery decks may be used to store small craft on board a ship however it cannot function as a full hangar as they are open to vacuum. A recovery deck is required for vessels using one or multiple launch tubes.

A recovery deck requires tonnage equal to four times the tonnage of the craft to be recovered at a cost of 0.5MCr per tonne. The minimum length of a recovery deck in meters is twice the tonnage of the small craft intending to be launched. It is designed to recover one craft every round and multiple recovery decks can be combined into larger recovery decks, each capable of recovering more than one craft at a time.

Design example – The Main Compartment – Hangar and Vehicles

Having a vehicle for the crew while on planetary surfaces is useful, so a standard hangar is provided allowing for the inclusion of a Grav Utility Vehicle.

Grav Utility Vehicle details = 4dT costing 0.28MCr.

Hangar (standard) = grav utility vehicle allocation + 10% = 4 + 0.4 = 4.4 rounded up to 5dT costing 1MCr.

Main Compartment – Hangar and Vehicles: Allocation = 5dT, Cost = 1MCr.



Cargo Hold

A ship's design must include any cargo capacity allocated to the ship, no matter how small that allocation is to be, and any space left over after all systems have been installed may be allocated to cargo space. This represents a basic hold with some fittings such as winches, bay doors, etc. Any allocated space for Cargo Holds is free. Cargo carried may not exceed cargo capacity.

However, it is possible to upgrade the basic cargo hold to a more specialist type. Cargo holds can be divided into a maximum of three differing cargo hold types if the basic hold space allocated is over 15dT. Except for the superior and armored hold, hold types can be interchanged as required. This will be a total cost of the current hold cost plus the new hold cost.

Cargo Hold Types

Type	Description	Cost per tonne (Cr)
Superior	Faster offloading and unloading	10,000
Armored	Difficult task DM -4 to break in. 5% of allocated cargo space	100,000
Liquid Cargo		8000
Livestock	See table below	
Freezer	See table below, life support halved, cost doubled	9000/dT
Concealed Compartment	Checks DM -2 Electronics (Sensors), DM -4 Investigate	20,000
External Cargo Mount		1000 per tonne

Superior Cargo Hold

This represents a better type of hold over the basic type allowing for faster loading and offloading of cargo. Installation includes small cranes and lifters for the cargo and better cargo ramps - often with a moving surface. Superior Cargo Holds cost 10,000 Cr per dT.

Armored Cargo Hold

A reinforced and armored hold is designed to withstand external damage and make intrusion more difficult. These are ideal for cargo that needs that extra level of protection, especially if it is valuable. The bay is lined with armor plating, braced walls and extra compartmentalization and every access point into the hold has superior security. Breaking into an armored hold is a very difficult task (-4) and any cargo damage hit rolled is halved. An armored hold requires 5% of the space allocated to cargo required and costs 0.1MCr per dT.

Liquid Cargo Hold

Normal liquid cargo will be carried in tanks that are stored in the hold. This option converts the entire hold into liquid storage. It can be pressurized or not. This means that there is no need for separate tanks that must be loaded individually. The contents of the hold must pump in or out via attachments on the hull of the vessel. This can be used to keep aquatic life forms in as well, either as accommodation or for captive tanks on hunting vessels for example. Liquid Cargo Holds cost 8,000 Cr per dT.

Livestock Hold

Designed for carrying live animals of various sizes, a livestock hold includes life support, feeding systems and sanitation. Cost and weight required is based on the size of the animals carried. Aquatic animals can be carried in Liquid cargo holds, just add the life support cost based on the size of animal.

Animal size	Example	dT per Animal	Cost per Animal	Life Support Cost per Month (Cr)
Tiny	Rabbit	0.1	0.01	10
Small	Dog	0.3	0.05	10
Medium	Sheep	0.5	0.1	10
Large	Cow	1.0	0.2	10
Huge	Elephant	3.0	0.5	10

Livestock Low Berth Hold

Designed for carrying live animals of various sizes but utilizing low berth equipment. Uses the same table as livestock holds, but two animals can be carried instead of one. Cost is doubled and life support cost is halved. For example, a small livestock hold designed to carry 8 sheep sized animals displaces 4dT, costs 0.8MCr and 320Cr per month live support costs. If the same hold is a Low Berth Hold, it can carry 16 animals, for 0.160MCr and 160Cr per month in life support costs. Aquatic animals can also be carried in low berths, for the same cost and tonnage as a land or air based equivalent sized animal.

Freezer Cargo Hold

Cold cargo is normally stored in containers that have freezer units. With this option the entire hold is a freezer, ideal for large cargo that will not fit in a container and adding a backup for containers that have freezer units if they fail. This is not a replacement for low berths and will not act like one. Freezer Cargo Holds cost 9,000 Cr per dT.

Concealed Compartment

An essential addition to a smuggler's vessel, concealed compartments are designed to be hidden from visual searches and shielded from sensors. This enables contraband and other, less legal items to be transported within. Space allocation towards concealed compartments cannot exceed 5% of a ship's tonnage, forcing a -2DM Sensors checks and -4DM to Investigate checks if a search is made. Concealed compartments cost 20,000Cr per dT.

Cargo Access Lock

Cargo hold hatches provide for easy loading and unloading of cargo and once a hatch is sealed the cargo hold itself becomes a large airlock in its own right. This however can cause complications if the vessel needs to move cargo in space or in hostile environments. To overcome this, a cargo hold

can be fitted with a cargo access lock, which provides a safe environment for any livestock cargo or for ship's crew working within the hold at the same time cargo is being unloaded or loaded.

A cargo access lock's space requirement is determined from the table below.

Cargo Hold Size (dT)	Access Lock Size
Under 20	2
20 - 50	8
51 - 100	12
101 - 300	26
301 - 500	20
501+	24

The access lock space requirement includes the airlock machinery, atmosphere pumps and deck space within the lock itself. Cost is 0.1MCr per dT.

Cargo Conveyor

Providing a quicker way to unload smaller cargo items or passenger luggage from a vessel, the cargo conveyor allows for rapid loading or unloading of such items reducing the number of cargo handlers required for such a task. A conveyor costs 15,000Cr and requires 1.5dT.

Modular Cargo Holds

Modular cargo holds allow a vessel to be outfitted quickly and at less cost to transport specific cargo types rather than refitting a standard cargo hold for the purpose. The modular bays are designed to ensure that the cargo modules can be swapped in and out quickly and efficiently.

A modular cargo hold requires an additional 10% of the total allocated cargo hold space for the attachment points and access points at a cost of 0.2MCr per dT.

For example, a ship with a 200-tonne modular cargo hold would require an additional space of $200 \times 0.1 = 20dT$ for the attachment and access points. Cost is $0.2 \times 20 = 4MCr$.

Overhead Cargo Crane

For larger cargo holds, it is often advantageous to be able to rearrange cargo internally or prepare cargo for loading onto grav or wheeled cargo lifters. Overhead cargo cranes are a low tech, low cost means to undertake these tasks.

Cargo cranes are most commonly installed on ships with cargo holds exceeding two hundred tonnes and are strong enough to lift the most common container sizes in use throughout the settled systems of Clement Sector.

Crane lift machinery requires 2dT with the overhead tracks and jigs requiring 0.5dT for every 200dT of cargo hold space. Overhead cargo cranes cost 0.8MCr per dT.

External Cargo Mount

Rather than carrying cargo internally, cargo mounts allow cargo containers to be carried externally of the ship. Cargo mounts are external racks or attachment framework allowing a smaller hull to be used, reducing transportation and ship operation costs. Neither streamlined nor distributed hulls can use external cargo mounts.

A ship that is being designed to carry cargo externally must consider the total combined tonnage of both the ship and the cargo it carries, and this will mean a maneuver drive with a lower thrust.

Any cargo carried externally can only be accessed from the outside of the ship EVA or a ship's small craft. Only certain types of cargo can be carried externally. Cargo that is more fragile still needs to be carried in internal cargo holds or by more expensive, specialist cargo containers that provide greater levels of protection for the cargo within.

Landing a ship with external cargo mounts is a riskier procedure (difficult task -2DM on all Pilot checks made for landing such a ship), so these ships often have difficulties trading at worlds without a cargo shuttle fleet or an orbital.

External cargo containers can be jettisoned remotely as each mount is equipped with explosive bolts, allowing specific cargo to be released if necessary.

The cost of an external cargo mount is 1000Cr for each tonne of externally carried cargo.

Design example – The Main Compartment – Cargo

Once all the allocation for the hull, engineering and the internal components is determined, the remaining tonnage is allocated to cargo. The trader has a standard cargo hold.

Cargo hold (standard) = 45dT

Main Compartment – Cargo: Allocation = 45dT

6. Ship's Crew

Civilian

The number of crew on a ship varies depending on its level of automation and complexity. It is possible to run a ship with a very small crew - a single scout can run a hundred-tonne scout ship, running from position to position - but if disaster strikes, a lightly crewed ship has a much slower response time than a fully crewed spacecraft. Independent traders and scouts tend to run with as small a crew as possible while corporate vessels will have an average-sized crew.

Civilian Ship Crews

Position	Minimum	Average	Full
Pilot	Pilot	Three pilots (one per eight-hour shift)	Three pilots, plus backups
Navigator	Expert Astronavigation program	One navigator	One navigator, plus backups
Engineer	One engineer	One engineer per 50 tonnes of drives	One engineer per 50 tonnes of Zimm drive, power plant and maneuver drive
Medic	None	One per 60 passengers	One per 60 passengers
Gunner	None	One per turret or bay	Two per turret or bay
Steward	None	One steward skill per two high or five middle passengers (see Clement Sector, page 454).	One steward skill per two high or five middle passengers (see Clement Sector, page 454).
Officers	None	One per 20 crew	One per 10 crew



Naval

The crew of a naval spacecraft must provide enough personnel to operate all machinery and operate all weaponry. The actual number of crew personnel required for the ship must be computed based on the drives, weaponry, and other equipment carried by the ship.

Command

The ship should have a commanding officer, an executive officer, a helm officer, a computer officer, two navigation officers and a communications officer. Command provides bridge and command support personnel and must include enlisted spacers and petty officers at least equal to 50% of the total officers in the section.

Engineering

The ship needs one engineering crewmember for each 25 tonnes of drives installed. This should include a knowledgeable chief engineer, a second engineer, and several petty officers. If the warship has a hull size more than 400 tonnes, then the Chief Engineer must be an officer.

Gunnery

The ship should have a chief gunnery officer and at least 1 petty officer for each type of weapon aboard. The gunnery department should have 10% officers and 30% petty officers.

- Turret and barbette weapons
Should have a crew of at least 1 per turret or turret type.
- Bay weapons
Should have a crew of at least 4.
- Spinal mount
Should have a crew of at least 2 per 100 tonnes of weapon
- Screen device (nuclear damper, meson screen)
Should have a crew of at least 4.
- Each operational fighter or turret drone
Requires at least 1 crew member

Flight Operations

If the ship has any launched craft, it should have a flight control officer, crew for each craft, and at least 2 maintenance crew per craft. If the ship is large enough to have a launch tube, flight deck, recovery deck or hangar deck then that ship would need a crew of at least 10, which will include a flight supervision officer and a preponderance of petty officers. Pilots must be officers and maintenance personnel are generally ratings.

In addition, if the ship has more than 3 vehicles (grav utility vehicles, ATVs, and so on), the flight section should include vehicle drivers and maintenance personnel for them as well (at least 1 per 3 vehicles).

Marines (Ship's Troops)

Most ships over 500 tonnes have a marine (or military) contingent aboard which ranges in size from a squad to a regiment. Such contingents shall be 3 per 100 tonnes. Ship's troops often fill the role of security forces aboard the ship and are used for planetside and in-space operations by the commander where necessary. Ship's troops are also used for damage control parties, operating of some weapons, and boarding actions.

Medical

This department provides medical support for crew during day-to-day operations and during combat operations. The size of the department is entirely dependent on the size of the ship's medical bay. On warships with more than five beds the department head will be a qualified naval doctor, though sometimes a naval doctor will be assigned to a ship with a medical bay with four beds.

Service Crew

The ship itself may have a requirement for other sections which provide basic services, including shops and storage, security (especially if there are no ship's troops aboard), maintenance, food service, and other operations. Allow 2 per 100 tonnes if there are no ship's troops. This can be reduced to as low as 2 crew per 150 tonnes of ship (rounded down) by replacing service crew with ship's troops for security duties.

Department	Base Crew
Command	14
Engineering	2/50 tonnes of drive
Gunnery	1/bay weapon, 1/turret or barbette, 4/screen, 2/100 tonnes of spinal weapon
Flight	Crew of craft, +2 mechanic per craft
Medical	1 per 2 beds, over 5 beds also requires a doctor (officer). See page 101 for additional crew requirements
Marines	Varies
Service	2-3 per 100 tonnes

Crew Accommodation

Officers

Officers, depending on rank, will share a stateroom with another officer, or if sufficiently senior, be provided their own stateroom. The captain of the ship must be provided with an individual stateroom, as must the executive officer, department heads and the commander of any ship's troops. Junior officers will share a stateroom with another junior officer.

Enlisted

Enlisted personnel are accommodated in eight bed crew berths. On some smaller naval vessels that have more conventional stateroom accommodation, two spacers will bunk in one stateroom.

Design example – The Main Compartment – Crew, Passengers and Accommodation

Now that all the drives and components are added a crew size and the correct accommodation allocation can be determined. Checking the Civilian Ship Crew table will provide crew requirements based on the ship design. For the best crew size a captain, navigator, engineer, medic, gunner and steward are needed. However if crew can double up on positions then that number could shrink to four. Up to ten middle class and ten low passage passengers can be carried.

Crew = 6 x standard staterooms (double rated) = 6 x 4dT = 24dT costing 3MCr.

Middle Passengers = 5 x standard staterooms (double rated) = 5 x 4dT = 20dT costing 2.5MCr.

Low Passengers = 10 x Low berths = 10 x 0.5dT = 5dT costing 10 x 0.05MCr. = 0.5MCr.

Main Compartment – Crew. Passengers and Accommodation: Allocation = 49dT. Cost = 6MCr.

Ship Software

Ship software operates in the same way as normal computer software but has a much higher rating. Ship computers are fully capable of running normal software as well and it is quite common for the ship's server to contain infotainment files, games and learning programs for the ship's crew.

Program	TL	Rating	Cost (MCr)	Description
Maneuver/0	8	0	Included	Allows basic control of ship
Intellect	11	10	1	Allows a ship to understand and obey verbal commands.
Zimm Control	9	10	0.2	Allows Zimm transitions. Incorporates astrogation software and Zimm Drive management.
Evade/1	9	10	1	The computer reacts automatically to incoming fire, applying a negative DM each round equal to the listed number.
Evade/2	11	15	2	
Evade/3	13	25	3	
Fire Control/1	9	5	2	Allows the computer to fire a number of weapons per round equal to the listed number. Alternatively, it can give a positive DM to an attack equal to the listed number, or any combination of the two. For example, a ship with Fire Control/3 could make three attacks, or give a +3 DM to an attack, or make one attack with a +2 DM.
Fire Control/2	10	10	4	
Fire Control/3	11	15	6	
Fire Control/4	12	20	8	
Fire Control/5	13	25	10	
Advanced Fire Control/1	10	15	12	The standard fire control package installed on most ships are perfectly suitable for control of several turrets but are inadequate in capability on larger vessels with multiple weapon systems. Advanced Fire Control software utilizes the more powerful computer processing capability of capital ships to increase the efficiency of the gunnery crews on those vessels allowing a DM to their attack roll equal to the listed number. Note that Advanced Fire Control does not allow a ship's computer to fire any weapons itself, merely increasing the accuracy of those operating the weapons.
Advanced Fire Control/2	12	25	15	
Point Defense/1	9	5	5	The computer reacts automatically to incoming fire, applying the software rating as a positive gunnery DM to defend the ship against incoming missiles. Requires a point defense node array.
Point Defense/2	10	10	15	
Point Defense/3	12	15	20	
Point Defense Drone/1	11	5	10	Controls up to 5 drones
Point Defense Drone/2	11	10	15	Controls up to 10 drones
Point Defense Drone/3	11	15	25	Controls up to 50 drones
Point Defense Drone/4	11	20	35	Controls over 50 drones
Defensive Screen	10	10	5	Automatically controls the MaGG screen mounted on a vessel, configuring it in response to incoming attacks. Acts as the equivalent Gunner (Screens) skill action with a +0DM.
Auto Gunner/0	9	5	1	Replaces a living gunnery crew though requiring +1 rating per ten gunners or part of. Acts with a skill level equal to the listed number and can use modifiers such as Advanced Fire Control.
Auto Gunner/1	12	10	5	
Launch Solution/1	8	5	10	Designed to ensure maximum impact to missile and torpedo attacks. All missile and torpedo salvos fired by the ship gain a DM to their attack rolls equal to the software rating.
Launch Solution/2	10	10	12	
Launch Solution/3	12	15	16	
Battlespace System/1	9	5	18	Designed to provide tactical level assistance for flagships, the Battle System software is an advanced suite of programs that interact with each other and ship systems to create a tactical view of fleet actions. Able to analyze and run simulations it can offer predictions so to advise officers as to the correct course of action. A Battle System provides a DM to Tactics (naval) checks equal to the Battle System Software rating (so, Battle System/2 grants +2 DM to the check).
Battlespace System/2	12	10	24	

Program	TL	Rating	Cost (MCr)	Description
Electronic Warfare/1	10	10	15	Utilizing the ship's sensor suites, this software provides sensor operators the means to locate and disrupt electronic systems on opposing forces vessels, missiles, and torpedoes. Electronic warfare actions (see Clement Sector, page 417) against vessels using this software gain a DM to a Sensors check equal to the software rating. For missile and torpedo launches, a single Electronic Warfare action with +0 DM is automatically performed against all enemy salvos launched within long range.
Electronic Warfare/2	12	15	18	
Auto-Repair/1	10	10	5	Allows the computer to make several repair attempts per round equal to the listed number. Alternatively, it can give a positive DM to a repair attempt equal to the listed number, or any combination of the two. Requires the ship to carry repair drones.
Auto-Repair/2	12	20	10	
Internal Security/1	10	2	6	Monitoring airlocks and external hatches, secure area access and ship software systems, the software will respond automatically to any attempts to hack ship systems or unauthorized access. Any skill check to access the ship's computer or restricted areas suffers a negative DM based on the Internal Security software rating.
Internal Security/2	11	5	8	
Internal Security/3	12	10	10	
Library	8	0	Included	Contains a wealth of data on numerous subjects.

Avatar Interface

Avatar interfaces in current use throughout Clement Sector form highly effective Human-Computer-Interfaces (HCI) allowing visual and audio sensory interaction with the ship's computer. To enable use of an Avatar, bridge holographic controls and ship's computer Intellect software are required.

Evolving from primitive 21st Century holographic displays used in commercial use, Avatars developed further as technology advanced to provide an effective means for crew to communicate and interact with their ship.

Common practice on military vessels is to maintain a standard shape and personality fitting with the polity's cultural and service regulations while civilian vessels can often be found to have a creative range of customized Avatars including fantasy, historical, and futuristic characters. An Avatar's personality can be tuned to fit a range of human emotions, and contrary to popular horror fiction across Clement Sector, there have been no recorded Avatars suffering mental illness or attempting to cause harm to their crews.

An Avatar is enhanced with Expert, Agent, and Intellect modules (Cement Sector, Page 338) and can be used as an adjunct to Intelligent Interfaces on starships. In addition, an Avatar can be programmed to take the form or shape of any human, with further packages available to customize the persona, clothing, size, and shape.

With the advent of Biosynth, Synthlink and Avatar AI Core technology, type 3 avatars representing the ship can now leave with the crew to provide enhanced access to ship's computing and knowledge resources as well as interact with the world outside. Just prior to the Collapse there were numerous rumors that some nations on the Earth side of the Conduit were experimenting with actual biological Avatars, but no hard evidence has been found for any such experiments. For more information see Independence Games' *Artificial: Robots in Clement Sector*.



The model number of the ship's computer dictates the maximum number of 'individual' Avatar personality interfaces that may be running on the ship at any one time. For example, a Model 4 Computer allows 4 distinct Avatars to be operating and on larger vessels these may be delegated to different responsibilities such as Bridge, Engineering, Service and Support, or Medical. This limitation does not restrict crew from accessing the same Avatar at the same time, so on a ship with a Model 1 Computer, multiple crew members may access the same Avatar from different locations of the ship.

Avatar Interface Type Table

Type	TL	Description	Cost (Cr)
1	11	Basic - limited to bridge and control points	12,500
2	12	Advanced - anywhere throughout a ship	80,000
3	13	Intelligent - as above with high levels of AI and awareness	400,000

Personality and appearance modules for an Avatar cost 500 Cr.

Within the Clement Sector, the main manufacturer of Avatar Interfaces and biosynth technology is Foreign Nobility Computers, a Bastiat-based company that supplies computer products throughout Clement Sector.

Design example – The Main Compartment – Software

A computer needs software to run ships systems, plot astrogation, gunnery targeting and compute Zimm transits. A basic suite of programs are included with the computer and the following support programs are also chosen from the Ship Software table.

Maneuver and Library (included)

Zimm Control = 0.2Mcr.

Fire Control/1 = 2Mcr

Intellect = 1Mcr.

Main Compartment – Software: Allocation = 3.2Mcr.



Costs and Maintenance

The owner of a starship faces a multitude of costs per month.

Item	Monthly Cost (Cr)
Mortgage or Debts	Varies
Life Support	2,000 per stateroom
	3,000 for berths, barracks, and double occupancy
	5000 per high class stateroom
	10,000 high class dining expenses
	100 per low berth
Fuel	500 per tonne of refined fuel
	100 per tonne of unrefined fuel
	Power Plant Fuel Cells 1200Cr per tonne per standard year
Maintenance	1/12 of 0.1% of ship's purchase price/month
Crew Salaries:	
Pilot	6,000
Navigator	5,000
Engineer	4,000
Steward	2,000
Medic	4,000
Gunner	2,000
Marine	2,000

Mortgage or Debts

If the crew are paying off debts on their spacecraft, then these debts must be paid each month. The standard terms for a ship mortgage are paying 1/240th of the cash price each month for 480 months (40 years). In effect, interest and bank financing cost a simple 120% of the final cost of the ship, and the total financed price equals 220% of the cash purchase price. Ship shares are treated as reducing the cash price of the ship, and so reduce the monthly cash payments.

Life Support and Supplies

Each stateroom on a ship costs 2,000Cr per month, occupied or not. This cost covers supplies for the life support system along with food and water, although meals at this level will be rather spartan. Each low passage berth costs 100Cr per month.

The above information is provided for quick monthly and maintenance calculations as part of ship design. For further details about starship operations refer to Clement Sector page 443.

Design example – Monthly costs

Now the ship is designed monthly costs must be determined. Referring to the Costs and Maintenance Table, the monthly repayments for the ship loan and the approximate costs per month to run the ship can be calculated.

Maintenance Cost = 0.007MCr (7000Cr).

Life Support Cost = 0.057MCr (57,460Cr).

Ship Loan = 0.34MCr (338,333Cr).

Capital Ship Section Hit Tables

Once design of the ship has been completed, the Section Hit table distributing both internal and external components must be laid out.

	Engineering		Forward		Other	
Roll	External	Internal	External	Internal	External	Internal
2	Hull	Crew	Hull	Crew	Hull	Crew
3	C	J-Drive	C	C	C	C
4	M-Drive	P-Plant	B	B	B	B
5	A	A	A	A	A	A
6	Hull	Structure	Hull	Structure	Hull	Structure
7	Armor	Hold	Armor	Hold	Armor	Hold
8	Hull	Structure	Hull	Structure	Hull	Structure
9	A	A	A	A	A	A
10	M-Drive	J-Drive	B	B	B	B
11	C	P-Plant	C	C	C	C
12	Hull	Critical	Hull	Critical	Hull	Critical

The table must be fully completed and contain no empty slots. Table entries marked Type A, Type B or Type C may contain one of the components as per the Component Table.

Excess Type A components can be placed into unused Type B slots and if there are not enough Type B slots then use unused Type C slots.

If all the ship's components are unable to be placed on the Section Hit table, then list the largest tonnage components.

If, after all components are placed into the Section Hit table there are empty slots then those internal and external slots are to be populated with structure and hull respectively.

Component Table

Type A		Type B		Type C	
External	Internal	External	Internal	External	Internal
Turret ¹	Bay ¹	Sensors	Spinal Weapon ⁴	External Special Component ⁵	Screen
Barbette ¹	Fuel	Craft ²	Hangar ²		Internal Special Component ⁵
	Hold	Launch Facilities	Power Plant ³		Command
		M-Drive ³	Zimm Drive ³		
		Spinal Weapon ⁴	Computer		

¹ Multiple weapon types of this mount (such as laser turrets and missile turrets) must be listed separately.

² Multiple types of this component (such as cutters and ship's launches) must be listed separately

³ The engineering section will normally contain all the ship's drives, however if any drive exceeds 10% of the ship's hull tonnage, it is to be placed in one extra section adjacent to the engineering section.

⁴ As a spinal weapon runs down the length of the ship it must be placed in the Internal Section Hit table for all sections apart from the engineering section.

⁵ Any component, such as a docking clamp, that exceeds 1% of the ship's hull tonnage then it is to be placed on the section Hit table.

Any component that has a role in ship-to-ship combat must be placed into one slot of the Section Hit table. These components include all weapons, sensors, small craft, launch facilities, computers, MaGG screens and bridges.

Capital Ship Crews

Crew Strength

A ship's crew size is measured on the Crew Strength Table

The size of the crew relative to the ship's required crew is measured on the Crew Strength table. Understrength crew may still be able to operate the ship, even with high levels of automation, but will have penalties to skill rolls or carry out tasks such as damage control more slowly. Overstrength crews will provide no bonuses but will be able to absorb more battle casualties. Such crews do; however, have a defense bonus during boarding actions.

Crew Strength Table

Crew Strength	Skill DM	
Dead	N/A	Cannot act
Survivors	-4	May only fire once every five turns
Skeleton	-2	May only fire once every three turns
Half	-1	May only fire once every two turns
Weakened	+0	
Full	+0	
Battle	+0	
Overstrength	+0	

Crew Skill Level

Starship crews are assumed to have average to good characteristics and have high specialist skill levels. It is common for individual spacers and officers to have lower or higher skill levels than the skill average for the ship, but the crew average is used for all crew skill checks.

Crew Skill	Skill DM
Green	+0
Average	+1
Experienced	+2
Elite	+3
Legendary	+4

If a crew has a particularly skilled commanding officer or department head (skill level of 4) then they will provide an additional +1 DM to one skill roll per turn. A skill roll can only benefit from one officer bonus only.

The gunnery officer on the HFS Moltke is a highly experienced officer with Gunner (Turrets) 4. "Guns" can then provide a +1 DM to one gunner check per turn.

Construction Time

While the accepted time calculation for civilian ship construction is one week per 5MCr of ship cost, construction times for custom and naval designs is based on their displacement and is listed below.

The first number is for a custom ship design or a class lead of a new class built in that yard and the second number is for further sister ships belonging to that class.

Size (tonnes)	Duration (weeks)
50 or less	24/15
60 to 80	32/19
90 to 100	40/24
200 to 300	48/29
400 to 500	64/38
600 to 700	96/58
800 to 900	112/67
1000 to 4000	120/72
5000 to 7000	144/86
8000 to 9000	152/90
10,000 to 15,000	160/96
15,000 to 20,000	170/100

Shipyards will naturally fast track any build providing that a fee is paid for the fast tracking to occur. Normally a yard charges 2.5% of the total cost of the ship construction.

During time of armed conflict shipyards are required to fast track naval construction, prioritizing naval hulls over any other projects.

Fast tracking allows a ship to be completed in 75% of the normal construction time.

Redecoration

A ship can have its interior redecorated at any shipyard. This will cost 0.25MCr for a standard finish or 0.5MCr for a luxury finish per tonne of area to be redecorated.

Exterior hull re-painting will cost 0.1MCr per tonne of hull.

Refit and Refurbishment

Often a ship will require more extensive maintenance than what is provided during regular monthly or annual maintenance cycles. This can often be a necessity, extending the life of the ship or to replace a major ship's system that has either failed or become faulty. Sometimes a new owner will modify the internal layout of the ship, adding more accommodation or increasing cargo capacity by reducing passenger accommodation.

It is at this time that upgrades can be undertaken to a ship's systems or components. These can be major such as upgrading a ship's maneuver drive or relatively minor such as replacing a computer core. A ship must have enough space available to install any additional or replacement system.

Such work can be undertaken at any shipyard depending on the complexity or scope of the work being undertaken. The largest shipyards such as Anderson and Felix Shipbuilders, Cascadia Orbital and Boone Ship Industries can undertake any refit or refurbishment work

Refit

More a Navy term rather than used by the civilian sector, a refit ensures a warship is at the peak of operational efficiency by extensive maintenance of all ship systems. Refits are undertaken when a ship returns to base after deployment and can take between four to six standard weeks to complete.

Refits cost four times the monthly maintenance cost of the ship that is undergoing that process.

Refurbishment

A Refurbishment ensures a ship's extension of life by replacement or upgrade of major and minor ship systems and sometimes reconfiguration of the ship (both internally and externally) to suit a different role.

Navy vessels undertake refurbishment as required. This can be as part of the life cycle of the ship in question or can be a major process that replaces older ship's systems with newer, more modern systems. For all navies refurbishment is a critical part of maintaining fleet strength.

It is important to note that if newer drive systems are to be installed, they may require a larger power plant to operate and this must be taken into consideration when upgrading those systems.

Installation of a turret onto a hardpoint and mounting of weapons into that turret does not incur additional costs. Turret weapon upgrades also do not incur additional costs, however upgrade of a hardpoint to a different weapon type will incur additional costs due to the amount of work required to undertake that task.



Refurbishment costs are outlined below.

Item	Procedure	Cost	Time Requirement
Armor	Additional	2x cost Additional armor cannot exceed 50% of the original armor value installed. One armor point maximum if no armor was originally fitted	1 day/5 tonnes
Drives	Removal and installation	1.5x cost of new drive required	1 week/10 tonnes
Power Plant	Removal and installation	1.5x cost of new power plant required	1 week/10 tonnes
Life Support	Removal and installation	0.25MCr/crewed space allocation	1 week/15 tonnes
Computer	Upgrade	1.5x cost of new computer required	1 week
Sensors	Upgrade	1.25x cost of new sensor suite required	1 week
Internal Components	Additional or rearranged	1.1x cost of component	1 week/10 tonnes
External Components	New	1.1x cost of component	1 week/10 tonnes
Hangar	New or expanded	0.3MCr per tonne of installation	1 week/10 tonnes
Launch Facilities	New or expanded	2x cost per tonne of installation	2 weeks/10 tonnes
Cargo	New or expanded	0.05MCr per tonne of installation	1 week/10 tonnes
Armament	Installation or change	Point Defense Nodes 1x cost	2 days/node
		Turret 1x cost	1 week
		Barbette 1.5x cost	3 weeks
	Upgrade	Bay 50-ton 2x cost	5 weeks
		Bay 100-ton 2.5x cost	8 weeks
		Bay 500-ton 6x cost	12 weeks
Ammunition Magazine	New or expanded	0.015MCr per tonne of installation	1 week/10 tonnes
MaGG Screen	Installation	2x cost. Military use only	2 weeks/10 tonnes

If the refurbishment upgrades or replaces a system that is in good working order, the shipyard will usually reimburse the owner 20% of the old systems cost. The cumulative costs of reimbursement will be deducted from the cost of the refurbishment. Less scrupulous (or perhaps even less legal) shipyards will certainly try and declare a system not worth reimbursement and on-sell it to another customer.

Replacement or upgrades do not have to be new. There is a thriving secondhand ship parts market in almost any of the settled systems of Clement Sector. The quality of these secondhand dealers ranges from very shady (not very legal) to extremely reputable and so prices and product quality will vary.

Reputable shipyards will offer reconditioned systems and components at 75% of the cost of new and this includes a warranty period of twelve months if the installed system or component fails.

As a general guide the cheaper the price of a system or component the more likely it will fail. If a purchased system or component is less than 50% of the cost of a new one, then roll a Mechanic task at Difficult every standard month using the highest Mechanic skill level in the ship's engineering crew. On any Failure or Exceptional Failure, consult Clement Sector, page 401 and 419 to affect repairs.

It is important to consider that local conditions will always affect a shipyards yard time and costs. A large shipyard such as Cascadia Orbital will generally be faster and cheaper than a smaller shipyard if the same quality materials and parts are used.



The Effect of Technology

Shipyards throughout Clement Sector construct hundreds of spacecraft per year. Almost all of these, including military purchases, use off the shelf standardized components to ensure that the spacecraft is constructed for a competitive price and can be maintained easily at any shipyard. Complicated licensing agreements will allow for a design to be constructed at several of the larger shipyards as well, so even more modern, newer designs are familiar. The ubiquitous Rucker-class merchant vessel for example can be built and maintained at most shipyards large or small.

Sometimes though, major shipyards such as Anderson and Felix Shipbuilders will construct demonstrator models featuring the latest technologies and advanced materials in the hope that it may be of eventual interest to either civilian or military sectors or to test those technologies. Governments or corporations may also commission the construction of such advanced spacecraft, either by interest in the demonstrators or by directly commissioning a shipyard to design and construct such a vessel. Conversely, prototypes of new technologies can be installed on ships several years or decades before those technologies are refined enough for more common use.

Technological Level Adjustments

To reflect the refinement of components due to increasing technology or the use of more advanced prototype technologies the technological level, price and tonnage of components can be adjusted during the design process. Components will also have advantages and disadvantages applied to reflect the effect of the use of higher or lower technologies. Each component and system listed in Anderson and Felix Guide to Naval Architecture has a minimum technological level that determines when it first becomes available for use. In practice though a component or system can appear at lower tech levels, but they would be less capable, less efficient, and often larger. Once that technology matures, improvements are then made available as technology progresses. At the present the current technology level of Clement Sector is 12 with computer and biological sciences levels considered 13.

There is a 5% discount (maximum 20%) per TL for older technology components or systems purchased new at source and purchase of second-hand outdated technology can be had for a fraction of the price (10% to 75% depending on condition or usability).

Drives

The Standard TL for maneuver drives is given in the Maneuver Drive TL Table.

<i>Maneuver Drive TL Table</i>						
	1	2	3	4	5	6
Maneuver	7	7	8	8	8	9

The Zimm Drive becomes commonly available at TL 9. No prototypes for a Zimm Drive are available for purchase.

Zimm Drive TL Table

	TL-1	TL +0	TL +1	TL +2	TL +3
Tonnage	200%	100%	95%	90%	75%
Cost	150%	100%	110%	125%	200%

There can be no improvements beyond TL +3

Power Plants

Fusion Power has been available for power generation since the middle 21st century and has been refined over the last three hundred years. Space vessels will always use the latest technology power plants, but it is possible to use older technology power plants if necessary or the ship is being constructed in a system with lower technology facilities and no economic means to procure better power plants.

Fuel requirements for capital ships are calculated after any tonnage reductions are applied.

Power Plant TL Table

	TL 8-10	TL 11-12
Tonnage	125%	100%
Cost	100%	100%

Armament

Becoming available as prototypes one tech level before becoming commonly available, weapons remain available for three tech levels before becoming outmoded or further progression becomes un-economical. Outmoded does not mean useless however and such weapons are still used as armament on both military and civilian space vessels.

	TL-1	TL +0	TL +1	TL +2	TL +3
Tonnage	200%	100%	90%	75%	60%
Cost	150%	100%	110%	125%	200%

For reference, the following table lists the tech level availability of weapons.

Weapon	TL	Weapon	TL
Pulse Laser	7	Sandcaster	7
Beam Laser	9	Mine Layer	8
Mining Laser	7	Missile	6
Particle Beam	8	Torpedo	9
Plasma Gun	11	Railgun	9
Fusion Gun	12	X-ray Laser	11
Meson Gun	11		

It is important to note that even though a launcher might appear at a certain tech level the tech level of the ordnance to be used will determine any size or cost reduction factors. If the ordnance is over one tech level higher than an earlier model launcher chosen, that ordnance type cannot be used in that launcher.

Instead of reducing tonnage of a weapon system a designer can elect to select to upgrade that weapon system. This reflects advancements in technology in the same way as reducing size. One upgrade may be chosen per tech level increase. Upgrades can be combined with size reduction if desired. If an upgrade/size combination is chosen, then tonnage reduction is reduced by one TL increase per upgrade chosen.

For example, a TL12 railgun bay could have a size reduction to 60%, or have three upgrades only, or have one upgrade and size reduction to 75% or two upgrades and size reduction to 90%.

Accurate (double Upgrade): Accurate weapons have a +1 DM to all attack rolls.

Easy to Repair: Easy to Repair armaments have a +1 DM to all repair attempts during combat.

High Yield: When rolling damage for a High Yield weapon, any '1's rolled are counted as '2's.

Long Range: The optimum range for a weapon is increased by one band.

Resilient (Double Range): The first hit on a Resilient weapon is ignored. Only Capital ship weapons can be Resilient.

Variable Range (Double Upgrade): A Variable Range Weapon increases its optimum range by one band in either direction.

Very High Yield (Double Upgrade): When rolling damage for a Very High Yield weapon, any '1's and '2's rolled are counted as '3's.



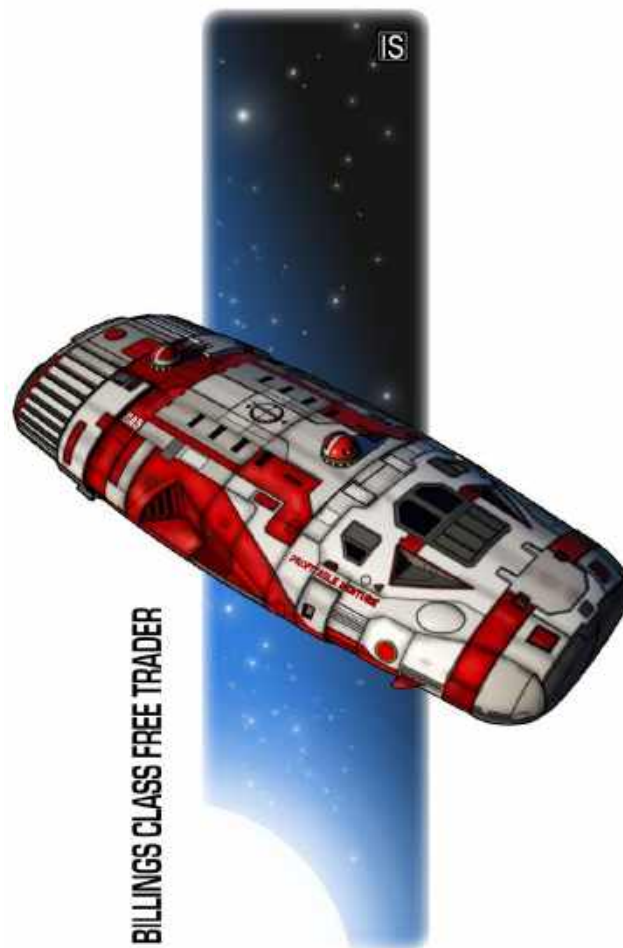
Design Example - The *Billings*-class Free Trader

The two-hundred-tonne *Billings* has been designed with a streamlined hull to allow for smooth and quick atmospheric transits to and from a planetary surface.

For defense against pirates, the *Billings* has crystaliron hull armor and can mount two turrets dorsally. Normally if purchased new there will only be one triple turret fitted to the ship's two hard points (beam laser/missile/sandcaster), usually on the rear dorsal hard point. Most *Billings* currently in service will have the other turret added to increase defenses. Space for any ammunition and fire control for the unfitted turret is included in the design.

Fuel tankage for the *Billings* provides fuel for a single transit of two parsecs and an operational duration of two weeks. Fuel scoops and on-board fuel processors allow for quick refueling of empty tanks to full tanks of refined fuel in just over two hours. The *Billings* can easily scoop fuel from gas giants and if necessary, planetary oceans.

Normally, the *Billings* is operated by a crew of six and can carry ten passengers in middle class comfort. All staterooms are designed for double occupancy. A further ten low berth passengers can also be carried.



Design Data

Hull and Armor

Type			Tonnes	Price (MCr)
Hull	200 Tonnes Code 2	Hull 4	200	8.8
	Streamlined	Structure 4		
Armor	Crystaliron x1	4 points	10	1.6
Hull and Armor Total			10	10.4

Engineering

Type			Tonnes	Price (MCr)
Zimm Drive	Type B	Max Two Parsec Transit (see below)	15	20.0
Maneuver Drive	Type C	Thrust 3	5	12.0
Power Plant	Type C	Power 3	10	24.0
Fuel	Powerplant	Two Weeks Duration	6	
	Zimm Drive	1x 2 Parsec Transition	40	
	Fuel Scoops	Included		
	Fuel Processors	1x (20 tonnes per day)	1	0.1
Engineering Total			77	56.1

Command

Type			Tonnes	Price (MCr)
Standard Bridge			10	1.0
Computer	Model 2(bis)	Rating 10 (+5 Zimm Control software)		0.2
Electronics	Basic Civilian	DM-2	1	0.1
Command Total			11	1.3

Armament and Defenses

Type			Tonnes	Price (MCr)
Weapons	Light (turrets)			
	Hardpoint 1	Triple turret mixed (beam laser/missile/sandcaster)	1	3.0
	Hardpoint 2	Not Fitted	1	
Ammunition	Magazines			
	Missiles	12x	1	
	Sandcaster Canisters	20x	1	
Armament and Defences Total			4	3.0

Crew and Accommodation

Type			Tonnes	Price (MCr)
Crew	6			
Passengers	Up to 20	10x Middle Class		
Accommodation	Staterooms	11x (rated to double occupancy)	44	5.5
	Low Berths	10x Low Class Passengers	5	0.5
Accommodation Total			49	6.0

Internal Components

Type			Tonnes	Price (MCr)
Internal Components	Medical Bay	1x Diagnostic Bed	2	0.5
	Ship's Locker	Included		
Cargo	45 tons		45	
Internal Components Total			47	0.5

Small Craft

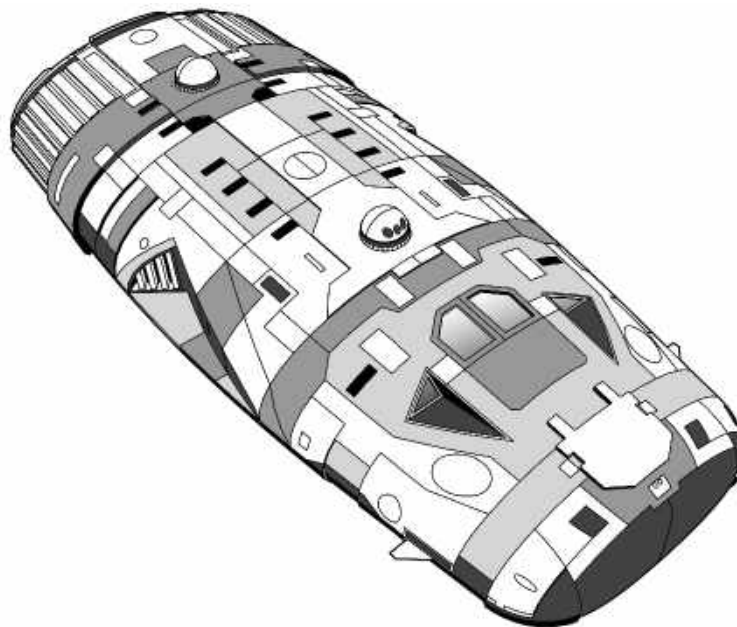
Type			Tonnes	Price (MCr)
Small Craft	Vehicle Hangar	Standard Hangar (1.1x vehicle)	5	1
		1x Grav Utility Vehicle (GUV)		
Small Craft Total			5	1

Software

Type			Rating	Price (MCr)
Software	Fire Control/1	DM+1	10	2.0
	Intellect		10	1.0
	Maneuver/Library			
	Zimm Control		10	0.2
Software Total				3.2

Totals

Type	Tonnes	Price (MCr)
Total Tonnage and Cost	200	81.7
Maintenance Cost (Monthly)		0.007
Life Support Cost (Monthly)		0.057
Ship Loan (Monthly)		0.340



Module 2 – Small Craft

The following is a module for designing small craft.

Definitions

A small craft is defined as any space vessel from 10 to 99 tonnes.

They are not ships as per the accepted definition used by both naval and mercantile organizations and are incapable of being able to form a stable Zimm Bubble. Data for the more common types used throughout Clement Sector can be found in Independence Games *Ships of Clement Sector 4-6: Traders, Scouts, and Small Craft*.

A 100-tonne spaceship design can be either a small craft OR a starship, it cannot be both. This must be specified by the designer before design commencement.

Size is measured in 'displacement tons' or dT: a hundred-ton ship displaces a volume equal to one hundred tons of liquid hydrogen (one dT equals roughly 14 cubic meters). Tons or dT in this supplement are interchangeable.

Fighter

Fighters are small, fast combat vessels with short range, normally displacing less than fifty tonnes. A fighter can be equally at home in space or a planetary atmosphere depending on the role it is designed to undertake.

Bomber

Bombers are heavier combat vessels usually with longer range and equipped with weapons that can damage a capital ship. They are not used by the Hub Federation Navy but are used by the Cascadian Defense Forces and by Monroe's System Defense Force.

Attack Boat

Pioneered by the Hub Federation, these heavy, fast, agile, and very powerful vessels are armed with either high-energy weapons or powerful ship killing torpedoes. The Hub Federation Navy is the only known navy deploying the torpedo armed version.

Boats

Boat is the collective term for auxiliary small craft ranging from 20 to 50 tonnes. They are long-range craft, designed for independent operations.

Lander

These larger small craft are used by the military to deploy troops and vehicles to planetary surfaces and orbitals. Heavily armed and armored, they can absorb damage and retaliate in kind.

Shuttle

A shuttle is a large cargo carrier, usually used to transfer cargo from orbit to surface.

The Design Process

Small craft are constructed on the foundation of a hull, into which are fitted the maneuver drives, the power plant, the fuel tanks, accommodation or seating for crew and passengers, control sensors and cargo space.

Optionally, other components such as armaments, defensive systems, and other fittings can be added to adapt the small craft to its intended function. The total tonnage of the installed fittings cannot exceed the tonnage of the hull.

Before commencing design, determine the role intended for the small craft and any associated specialization that role might require.

1 . The Hull

- a. Choose Hull size and configuration.
- b. Install armor and any hull options.

2. Drives

- a. Choose drives and power plant. If designing a reaction drive vessel then refer to the small craft section in module 3 – reaction drive for drive type selection.
 - i. Decide what the maximum acceleration for the ship should be, and cross-reference it with the ship's tonnage on the Performance by Hull Volume Table to determine the Maneuver Drive required.
 - ii. Choose a Power Plant, ensuring that it can provide enough power for the Maneuver Drive.
- b. Fuel
 - i. Calculate fuel requirements and allocate space for fuel (reaction drive vessels also require reaction mass).

3. The Main Compartment

- a. Install a control cabin or cockpit.
- b. Install a computer.
- c. Install computer software.
- d. Install sensors.

- e. Install cabin internal components such as staterooms, heads, airlock, passenger seating type and number (cabin space or acceleration couches) and fuel processors.

4. Armament

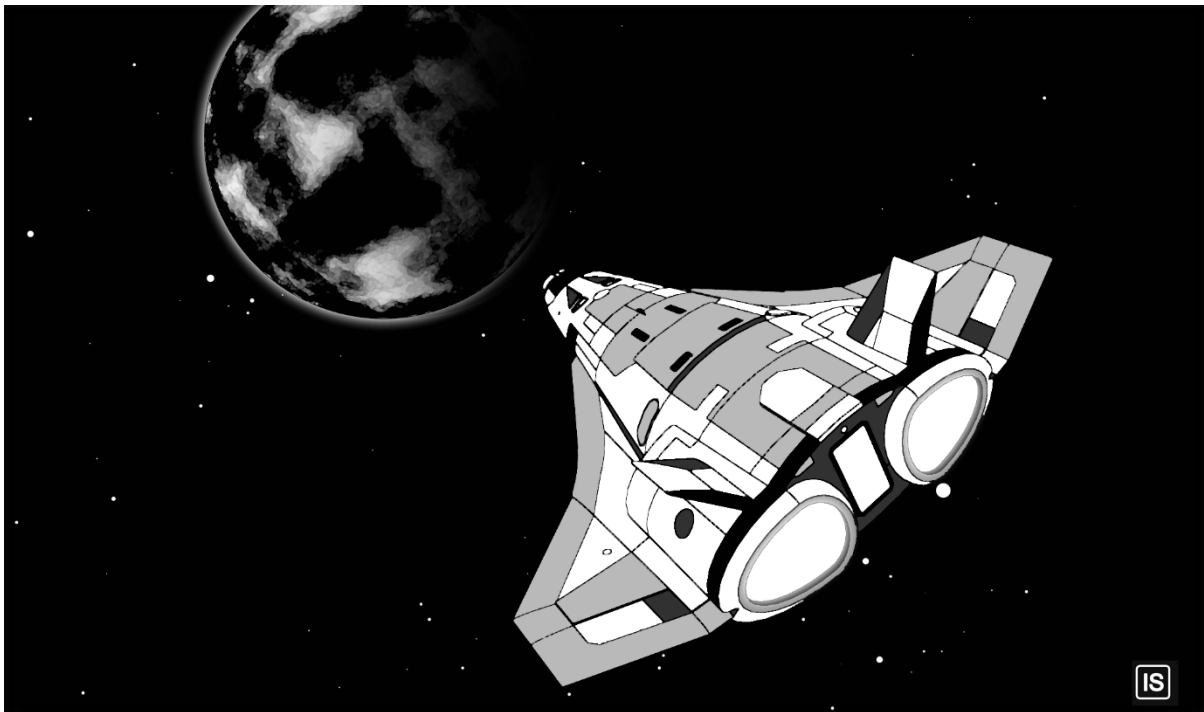
- a. Determine number of ship-weapons, small craft weapons and anti-personnel weapons allowed for the hull size. Note restrictions on weapon types.
- b. Ensure one tonne of fire control per turret, barbette, or bay.
- c. Install weapons.
 - i. Missile launchers, torpedo mounts, railguns and sandcasters require ammunition.
 - ii. Add any small craft weapons if required.
 - iii. Install anti-personnel weapons if required.
 - iv. Anti-personnel missile types to be noted along with any ammunition needed for other anti-personnel weapons.

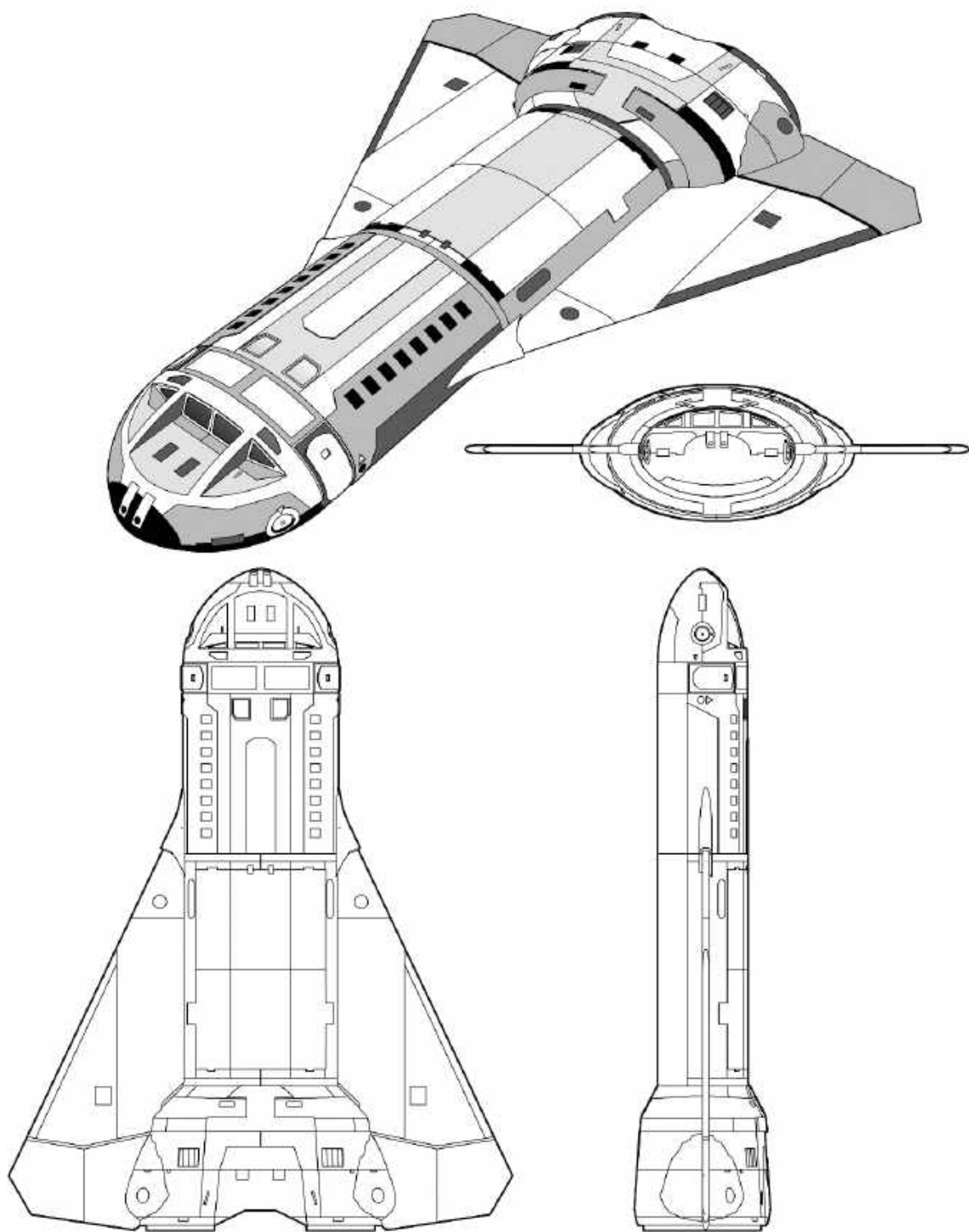
5. Crew and Cargo Space

- a. Determine crew required to operate the small craft effectively.
- b. Any remaining space can be allocated to cargo

Design example

Having received a design order for a custom small craft from a client, the naval architect, on discussion with the client determines that a 30 tonne (dT) hull would be a suitable choice. This would allow enough room for the requested high thrust drive, the crew, passengers, and a small cargo capacity for the ship's displacement.





1. The Hull

Hulls are identified by their displacement, expressed in tonnes (dT).

Hull Costs			Small Craft
Hull (dT)	Hull Code	Price (MCr)	
10	S1	1	
20	S2	1.2	
30	S3	1.3	
40	S4	1.4	
50	S5	1.5	
60	S6	1.6	
70	S7	1.7	
80	S8	1.8	
90	S9	1.9	
100	S10	1	

Configuration

There are three main types of hull configuration available for a small craft which are identical to ship hull configurations:

- Standard (a cone, sphere, or cylinder)
- Streamlined (a needle/wedge, wing, disk or lifting body)
- Distributed (made up of several distinct sub-sections)

Standard Hulls

Spacecraft of this hull type can land and leave a planet with an atmosphere but cannot maneuver within that atmosphere, gaining no assisted lift from the atmosphere.

Streamlined Hulls

Spacecraft of this hull type can land, leave and maneuver in any atmosphere. Streamlining must be included at the time of construction and increases the cost of a hull by 10%. All aerospace fighters will be streamlined. Fuel scoops are a free option but must be nominated during design.

Distributed hulls

Close Structure Hull configured small craft struggle within any atmosphere type and tend to be used in space only. Selecting this hull configuration reduces the cost of the hull by 10%.

Small craft with a Dispersed Structure hull cannot land on any planetary surface or enter any atmosphere type and craft of this configuration are used in space only. Selecting this hull configuration reduces the cost of the hull by 50%.

Reaction drive small craft have further hull configuration options that affect their performance within planetary atmospheres due to the lack of the “lift” ability of a gravitic drive. See module 3 for these options if designing a reaction drive small craft.

Hull and Structure

Hull and Structure points are determined by a small craft’s hull displacement. During combat any damage suffered by a small craft will be reflected by losses to those point values. Initially, damage is applied to the Hull and once the Hull is breached further damage is applied to the small craft’s Structure. If all Structure Points are lost, then the small craft is considered completely destroyed.

Hull and Structure Table

Tonnes (dT)	Personal Scale		Ship Scale	
	Hull	Structure	Hull	Structure
10	10	30	0	1
20	20	35	0	1
30	30	40	0	1
40	40	45	1	1
50	50	50	1	1
60	60	60	1	1
70	70	70	1	1
80	80	80	1	1
90	90	90	1	1
100	100	100	2	2

Armor

The basic hull provides some protection from anti-ship weapons fire, but it is possible to add heavier armor to the hull for added defense. Navy small craft will always have added armor, the amount depending on the role and size of the vessel. For example, an assault lander would have heavy armor to ensure it survives ground fire.

The amount of armor that can be added to a small craft is determined by the technological level of the type of armor added. This is defined by the table below.

Armor Type	TL	Protection	Cost	Maximum Armor
Titanium Steel	7	2 per 5% ¹	5% of base hull	TL or 9 whichever is less
Crystaliron	10	4 per 5% ¹	20% of base hull	TL or 12, whichever is less

¹ Or one tonne, whichever is greater

There is no requirement to add armor in 5% elements, but it must be added in whole armor point values.

For example, the minimum element which can be added for Titanium Steel is 2.5%, which is a single point of armor.

Any selected armor options must be added during the installation of the ship's armor and cannot be easily retrofitted.

Hull Options

Small craft may have any of the hull options available to spacecraft.

Design example – The Hull

Deciding on a standard ships boat 30dT hull, the designer adds streamlining as the small craft would need to be able to enter atmosphere. This adds 10% to the hull cost. They then add 4 points of crystaliron armor to further protect the ship.

Hull Cost table = Hull Code S3, 30dT costs 1.3MCr.

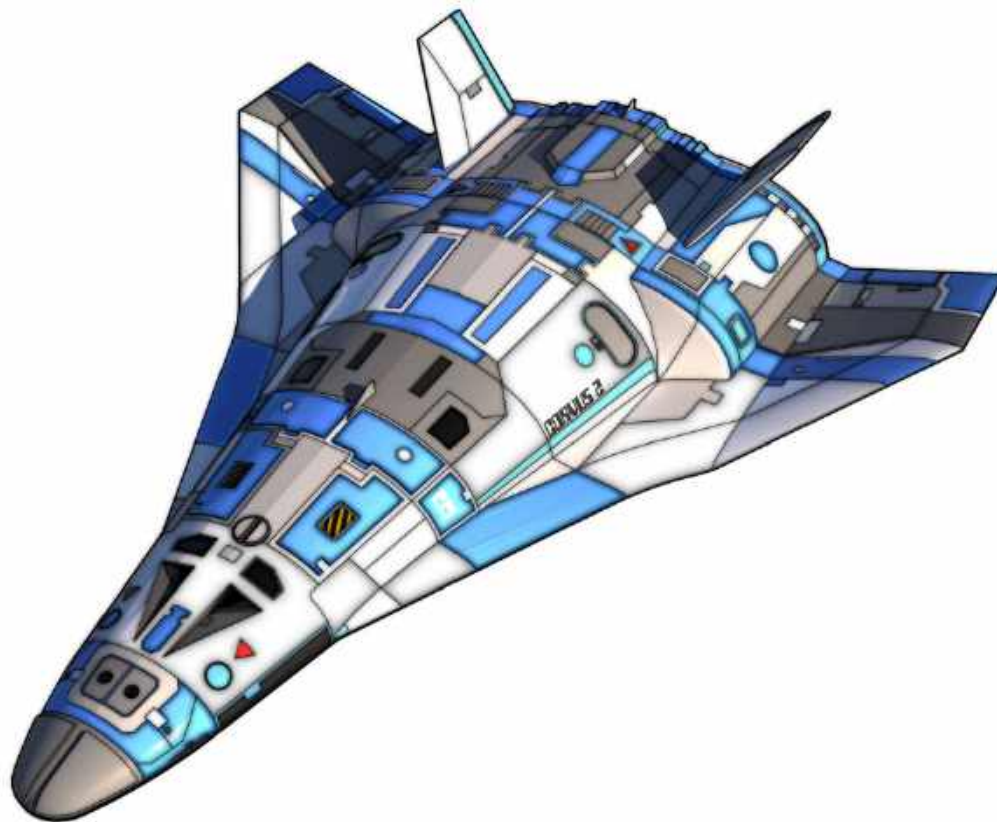
Streamlined configuration = 10% x hull cost = 0.13MCr.

Hull Points = from table = 0

Structure Points = from table = 1

Armor = Crystaliron 5% x hull tonnage at 20% x hull cost = 1.5dT for 0.3MCr.

Hull summary: Allocation = 1.5dT, Cost = 1.7MCr.



2. Drives

Maneuver Drives

A small craft cannot be equipped with a Zimm Drive. It can be equipped with a Gravitic or Reaction maneuver drive or, for solar boat enthusiasts, a solar sail.

Gravitic drive

Small craft gravitic drives are smaller versions of the drive plates used by larger spacecraft and propel the craft using artificial gravity. Unlike ships, small craft drives can achieve much higher thrust ratings.

Reaction drive

A Reaction drive ejects matter rearwards of the small craft at high velocity but burns fuel much more quickly and are less efficient. See Module 3 for small craft reaction drive design options.

Solar Sail

Solar Sails are large and can be up to several kilometers across. Made of a flexible synthetic fabric that has limited self-repair capabilities, the sail is designed to catch particles emitted by the sun (the 'solar wind') which provides an extremely small amount of thrust. Any ship using a solar sail as its primary method of propulsion has a thrust of 0, requiring several days or weeks to change its course or speed. A solar sail costs 0.01MCr per tonne of ship and requires an allocation of 5% of the ship's total tonnage when stowed.

Solar Boat Racing

A popular sport throughout the more affluent systems of Clement Sector, solar boat sailing regattas and racing competitions are held every four years in Wellington system in the Hub Federation. The Cascadian Cup held in the Cascadian system is also a very popular competition that is held every four years. Both events attract hundreds of competitors throughout the Hub, Franklin, and Cascadia subsectors.

Power

Just like larger spacecraft, a small craft must have a power source.

The standard power plant for any spacecraft is the fusion reactor. Compact, efficient, and powerful, it will provide more than adequate power for all systems. There are alternative sources of power for a small craft available listed below.

Chemical Plants

Chemical plants use petrochemical or synthetic fuels. Chemical plant fuel cannot be skimmed from gas giants or taken from water sources and cannot be used by reaction drives. These are very low technology power plants.

Chemical Batteries

Storing electrical energy, chemical batteries provide power for the ships maneuver drive and ship systems. They will need to be recharged after use. These can be perfect for a backup system, providing power for emergency situations.

The sizes of chemical batteries are based on the power plant required to deliver a performance rating of 1. A chemical battery the same size as a fusion power plant of the same tech level will provide 1000 hours of use assuming the vessel is not maneuvering, using active sensors, refining fuel, making significant use of long-range communicators or energy using weapons (such as lasers, rail guns, and particle beams). Alternatively, the same sized battery will give 1 hour of performance without these restrictions.

A battery can be scaled in size to give any endurance and costs 4 times the equivalent fusion power plant. A TL7 battery is the same size as a TL 8 battery.

For example, a sB battery with 2000 hours of endurance will require $(1 \times 2000/1000) = 2$ tonnes and cost $(2 \times 2000/1000 \times 4) = 16\text{MCr}$

The time to recharge a battery is equivalent to the battery endurance used (in low power setting) divided by 1000 divided by the power plant rating multiplied by 2. If using solar panels to recharge the battery, the “power plant rating” is 0.1.

For example, the battery described above has been used for 1600 hours. To recharge it with solar panels will require $(1600/1000/0.1 \times 2)$ 32 hours.

Solar Panels

Solar panels are extendable panels that provide power as a backup to a chemical plant, fusion plant, as a recharging source for chemical batteries, or if the power requirement is very low, as an independent power source.

The size of solar panels required to power a ship is 1/10th that of the main power plant. A craft equipped with auxiliary solar panels consumes power plant fuel at one-quarter the normal rate if it is only engaged in minimal maneuvering activity only. Minimal maneuvering does not include long periods at full thrust. No power plant fuel is consumed, and endurance is considered as infinite, if the ship is not maneuvering, using active sensors, or refining fuel for use.

If the panels are fitted to a ship without a chemical or fusion power plant, then assume that the solar panels are equivalent to a fusion main power plant sized to deliver a performance rating of 1. Solar panels cost 0.1Mcr per tonne.

Small Craft Drive costs and Tonnage

Drive Code	Gravitic M-Drive		Fusion P-Plant		Chemical P-Plant	
	Tonnage	Mcr	Tonnage	Mcr	Tonnage	Mcr
sA	0.5	1	1.2	3	2	1
sB	1	2	1.5	3.5	2.5	1.25
sC	1.5	3	1.8	4	3	1.5
sD	2	3.5	2.1	4.5	3.5	1.75
sE	2.5	4	2.4	5	4	2
sF	3	6	2.7	5.5	4.5	2.25
sG	3.5	8	3	6	5	2.5
sH	4	9	3.3	6.5	5.5	2.75
sJ	4.5	10	3.6	7	6	3
sK	5	11	3.9	7.5	6.5	3.25
sL	6	12	4.5	8	7	3.5
sM	7	14	5.1	9	7.5	3.75
sN	8	16	5.7	10	8	4
sP	9	18	6.3	12	8.5	4.25
sQ	10	20	6.9	14	9	4.5
sR	11	22	7.5	16	10	5
sS	12	24	8.1	18	11	5.5
sT	13	26	8.7	20	12	6
sU	14	28	9.3	22	13	6.5
sV	15	30	9.9	24	14	7
sW	16	32	10.5	26	15	7.5
sX	17	34	11.1	28	16	8
sY	18	36	11.7	30	17	8.5
sZ	19	38	12.3	32	18	9

Small craft hulls vary in their requirements for drives and power plants based on tonnage and any specific drive will be less efficient as the tonnage it must create thrust for increases. The drive potential table lists 24 standard maneuver drives and power plant types, identified by the letters A through Z (omitting I and O to avoid confusion). Also listed are various tonnage levels for hulls; any tonnage which exceeds a listed level should be read at the next higher level. Correlating hull size with drive letter indicates drive potential. If a hyphen (-) is listed, then that combination of drive and hull will result in a vessel with insufficient power or overpowered.

For maneuver drives, the potential is the Thrust number, which is the number of G's acceleration

- For maneuver drives, this potential is the Thrust number, which is the number of gravities (G) thrust (acceleration) available for that drive type.
- For power plants, it is power plant rating. The power plant rating must be at least equal to the maneuver drive.

	<i>Performance by Hull Volume</i>									
	10	20	30	40	50	60	70	80	90	100
sA	2	1	-	-	-	-	-	-	-	-
sB	4	2	1	1	-	-	-	-	-	-
sC	6	3	2	1	1	1	-	-	-	-
sD	8	4	2	2	1	1	1	1	-	-
sE	10	5	3	2	2	1	1	1	1	1
sF	12	6	4	2	2	2	1	1	1	1
sG	-	7	4	3	2	2	2	2	1	1
sH	-	8	5	3	3	2	2	2	2	2
sJ	-	9	6	3	3	3	2	2	2	2
sK	-	10	6	5	4	3	3	3	2	2
sL	-	11	7	5	4	3	3	3	3	3
sM	-	12	8	6	4	4	3	3	3	3
sN	-	13	8	6	5	4	4	4	3	3
sP	-	14	9	7	5	4	4	4	4	4
sQ	-	-	10	7	6	5	4	4	4	4
sR	-	-	10	8	6	5	5	5	4	4
sS	-	-	11	8	6	5	5	5	5	5
sT	-	-	12	9	7	6	5	5	5	5
sU	-	-	12	9	7	6	6	5	5	5
sV	-	-	13	10	8	6	6	6	5	5
sW	-	-	14	10	8	7	6	6	6	5
sX	-	-	14	11	8	7	6	6	6	6
sY	-	-	15	11	9	7	6	6	6	6
sZ			16	12	9	8	6	6	6	6

Note that small craft under 70 tonnes can achieve thrust ratings greater than 6. This is not possible on larger hulled vessels due to hull stress limitations.

Fuel

Total fuel storage for a small craft must be shown on the design plans. Providing fuel tankage has no cost but the capacity of fuel tankage will determine how frequently that craft is required to refuel.

Gravitic maneuver drives do not require fuel. However, a reaction drive requires reaction mass to provide thrust. See module 3 for reaction drive reaction mass requirements.

Fusion Power Plant

The amount of fuel required by the power plant is determined by the rating of the power plant and the length of the small craft's operation. The table below lists the amount of fuel needed to power the small craft for two weeks.

sA	sB	sC	sD	sE	sF	sG	sH	sJ	sK	sL	sM	sN	sP	sQ	sR	sS	sT	sU	sV	sW	sX	sY	sZ
1	1	1	1	1.5	1.5	1.5	1.5	2	2	2	2	2.5	2.5	2.5	2.5	3	3	3	3	3.5	3.5	3.5	3.5

Chemical Power Plant

The amount of fuel required by the power plant is determined by the rating of the power plant and the length of the craft's operation. The table below lists the amount of fuel needed to power the small craft for two weeks.

sA	sB	sC	sD	sE	sF	sG	sH	sJ	sK	sL	sM	sN	sP	sQ	sR	sS	sT	sU	sV	sW	sX	sY	sZ
5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120

When not using active sensors, weapons or more than occasional use of very long communication, craft with chemical power plants halve their fuel consumption. For example, normally a 90-tonne shuttle with a chemical power plant (rating sE), would require 25 tonnes of fuel for 2 weeks endurance. However, as it does not need active sensors except when docking, will rarely use weapons or very long-range communicators, 12.5 tonnes will be sufficient for 2 weeks endurance.

If you are reducing power plant fuel to several hours, endurance will be important, so multiply the number of hours of fuel by 10 to give the number of turns of operation at full power.

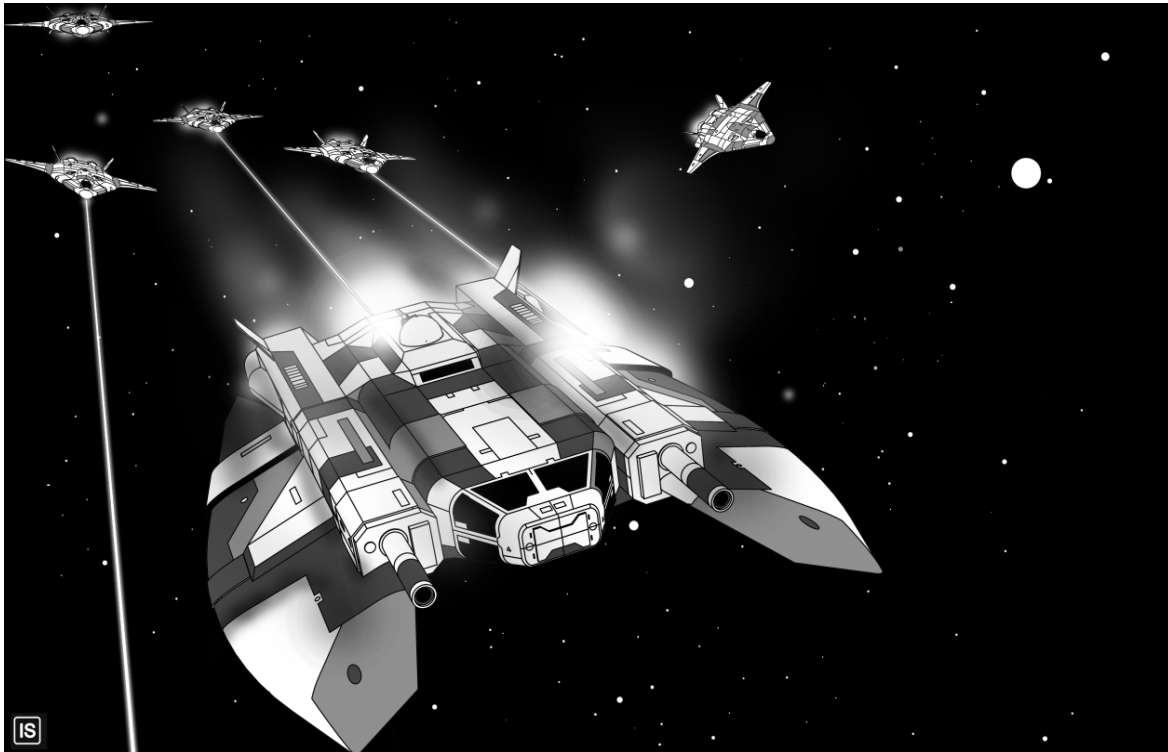
Small Craft Fuel Requirements

Small craft often do not need to function for two weeks of independent operations. A surface to orbit shuttle or a fighter might only need to carry enough fuel for a few hours of flight.

Operation Time	% of Base Requirements
Three hours (surface to orbit)	1
Six hours (dogfighter)	2
12 Hours (surface to orbit round trip + maneuvering or an aerospace fighter)	5
One day (Standard vehicle operations)	10
Three days	25
One week	50

For example, an auxiliary boat with a type sK power plant requires two tonnes of fuel for two weeks of operation. If it only requires one week of operation, then it requires only one tonne of fuel.

A Hub Federation Marine Corps FA-135C Reaver aerospace fighter with a sG power plant requires 1.5 tons of fuel for two weeks of operation. However, the fighter needs only to operate for one day before refueling, so it only needs 10% of this fuel, or 0.15 tonnes of fuel.



3. The Main Compartment

The small craft's main compartment contains all non-engineering features of the craft, including the control cabin, computer, sensors, passenger accommodation, armament, cargo hold and other items.

Cockpit or Control Cabin

All craft must have either a cockpit or a control cabin containing basic controls, communications equipment, avionics, scanners, detectors, sensors, and other equipment for proper operation of the ship. A cockpit is much more cramped and uncomfortable but takes up less tonnage. No extra passengers can be carried in a cockpit; a control cabin allows for half as many passengers as crew to be carried. The cost for a cabin or cockpit is the same - 0.1MCr per 20 tonnes of ship.

A cockpit takes up 1.5 tonnes per crewmember and a cabin takes up three tonnes per crewmember. The cockpit or control cabin includes a basic electronics suite. More advanced electronics suites can be installed (as per the rules for starship electronic suites).

Cabin Space

Adding cabin space gives the crew more space to move around and to access other components of the ship, such as the engines or cargo bay. Every 1.5 tonnes of cabin space allows the craft to carry another passenger in moderate comfort. Designating a section as cabin space costs 0.05MCr per tonne.

A small craft may have acceleration couches or seats for short duration passengers (such as for surface-to-orbit voyages) or for deploying troops. Couches are not comfortable but are a safe means of transporting larger numbers of passengers. Each couch is heavily padded with integral safety harnesses to prevent passenger injury in case of internal gravity failure or a rough descent through a planetary atmosphere.

Normally designed to fold down from walls or pull up from floors to grant more useable space when not in use. Acceleration couches seat six passengers, take up one tonne and cost 10,000Cr each.

Acceleration Seats are more comfortable than acceleration benches but are less space efficient. These take up 0.5 tonnes, cost MCr 0.03MCr and seat one passenger.

Airlock

Unlike starships, a small craft does not have an airlock by default. If a craft does not have an airlock, then the crew cannot leave the craft except when it is landed or in a pressurized landing bay without opening the ship up to vacuum.

Standard

A standard airlock provides enough room for two people at any one time. Airlocks take up one tonne each and cost 0.2MCr.

Boarding Airlock

A boarding airlock allows troops to enter a vessel being boarded more quickly. Boarding airlocks take up two tonnes each and cost 0.4MCr.

Internal Components

The cabin space of a small craft can be customized for the role it is intended to undertake. Many designs like the ubiquitous modular cutter can be customized by utilizing swap out modules for a variety of roles as required. Other small craft rely on adjustable interior bulkheads and fittings to shift from cargo, passenger, or combined roles. Larger small craft intended for long duration journeys or missions will have full staterooms, recreation and galley areas for crew and passengers.

Small Craft Stateroom

Like the standard stateroom on bigger space vessels, the small craft stateroom requires two tonnes and costs 0.25MCr.

Heads

These are self-contained fresher facilities located within small craft cabin space and used by crew and passengers. There are two types:

- Toilet facilities only, displacing 1dT and costing 0.05MCr.
- Toilet and shower facilities, displacing 1.5dT and costing 0.1MCr.

Fuel Processors

Small craft with fuel scoops and using a fusion power plant can have fuel processors installed to extend operational time. Small craft fuel processors can process 2dT of fuel per day at a cost of 0.1MCr per 0.5dT installed.

Small craft may have any of the internal components allowed to larger vessels.

Design example – The Main Compartment – Control Cabin and Cabin Space

A control cabin along with a Model 1 computer will be installed. For the ship's boat, a standard sensor suite is all that is required.

Control Cabin = 6dT = 2 crew positions 1.5dT costing 0.1Mcr per 20dT hull size = $0.1 \times 30/20 = 0.15\text{Mcr}$.

Computer Model 1 = 0.03Mcr.

Computer Software = Library, Maneuver

Sensors (Standard) = Included in control cabin cost.

Airlock (Standard) = 1dT costing 0.2Mcr.

Control Cabin:

Passenger Seating = 12 passengers at 0.5dT $12 \times 0.5 = 6\text{dT}$, costing 0.03Mcr each seat = $12 \times 0.03 = 0.36\text{Mcr}$.

Internal Components:

None

Main Compartment – Control Cabin, Computer, Sensors and Cabin Space: Allocation = 14dT, Cost = 0.74Mcr.



4. Armament

The number of weapons allowable depends on the size of the craft. Weapons are divided into two categories - ship weapons and anti-personnel weapons. Anti-personnel weapons like plasma support weapons or rocket launchers are too short ranged and low powered to be of use against spacecraft.

Point Defense Nodes are not available for small craft and cannot be installed.

One tonne of fire control equipment must be installed for each turret or fixed mount (see page 68). Anti-personnel weapons do not need to be placed in turrets - instead, they are mounted on the external surface of the craft in pop-up mounts like PD node mounts on ships or weapon bays similar to atmospheric fighters. One turret is required per three weapons carried.

Small Craft Size	Ship Weapons	Small Craft Weapons	Anti-Personnel Weapons
10	1	1	2
20	1	1	2
30	1	1	2
40	2	3	3
50	2	3	3
60	2	3	3
70	3	4	4
80	3	4	5
90	4	5	6
100	5	6	6

For anti-personnel class weapons refer to Independence Games' *Clement Sector* page 306 or Moon Toad Publishing's' *Cepheus Engine: Vehicle Design Guide*. Anti-personnel, anti-armor and anti-air missiles must be installed into enclosed bays to protect the missiles from the heat of re-entry. Anti-personnel (vehicle or ground force) weapons must resolve combat outcomes and damage using the *Cepheus Engine: Vehicle Design Guide* (VDG) combat system. See page 110 of the **VDG** for information regarding ground force weaponry against spacecraft scale targets.

Small Craft Weapons (SCW) are less powerful than ship class weapons but are more capable than anti-personnel weapons. Selection of anti-personnel weapons is limited to cannon under 50mm caliber, including all gauss cannon and rail guns. Meson, particle beam, fusion or torpedo bays cannot be fitted. Refer to pages 141-142 for missile or rail gun bay requirements and details.

The selection of available ship weapon types that can be installed on a small craft is restricted. Barbette Particle beams can be fitted but use the equivalent of two ship weapons (and a turret) and a small craft can only mount a maximum of two particle beam weapons depending on the size of the small craft. Torpedo barbettes cannot be fitted but individual torpedoes can be carried. Each torpedo displaces 2.5 tonnes and uses a ship weapon slot.

Meson, particle beam and fusion bays cannot be fitted.

The armaments allowed to small craft are further restricted by its power plant type. It may only equip up to the number of ship-scale energy weapons (such as lasers and particle weapons) that are allowed by the following table. The number of missile launchers or projectile weapons is not limited by the power plant letter.

Power Plant Code	Energy Weapons
A - F	0
G - K	1
L - R	2
S - Z	3

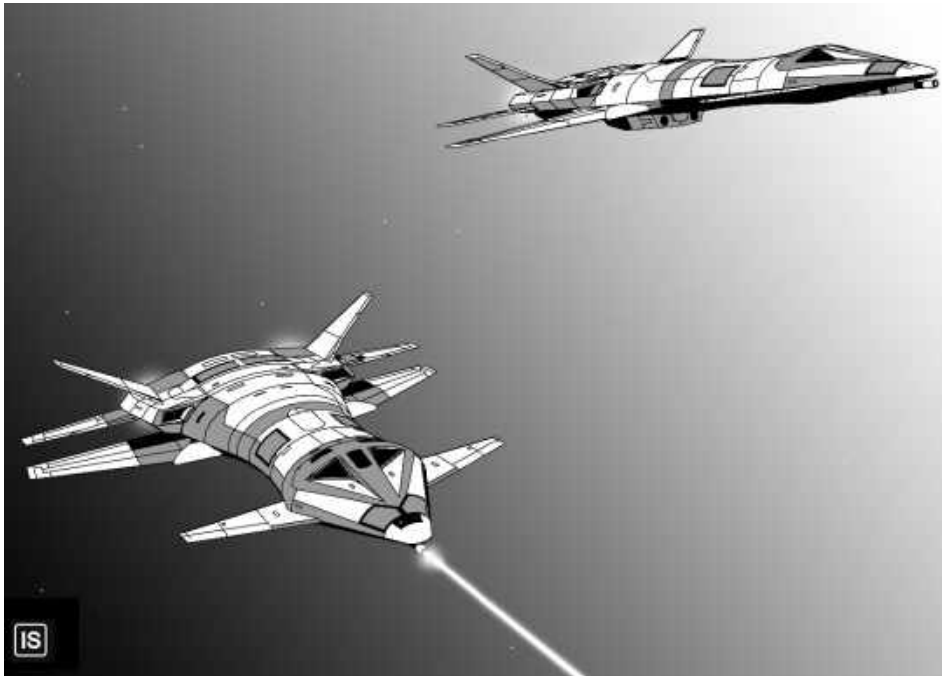
Particle beam barbettes are the equivalent of 2 energy weapons each.

For example, a 70-tonne lander has a Class sH power plant. It may install up to three ship weapons, but a maximum of one of these can be energy weapons.

Small Craft Weapons (SCW)

Less powerful than ship class weapons, but more capable than anti-personnel weapons, small craft weapons (SCW) allow small craft to be able to carry a wide variety of direct fire and missile systems more capable of inflicting damage or destroying opposing small craft. Given enough damage caused by multiple strikes, smaller spacecraft can also fall prey to small craft armed with SCW.

If a ship class weapon is not installed as part of the small craft design, then the number of small craft weapons available to its hull tonnage doubles. The exception is when SC Particle Beams are to be installed (see below). Unlike ship class weapons, SCW do not require fire control tonnage allocation.



SC Missiles

First some calculations.

A single ship class missile is 0.083 tonnes or 12 missiles per one tonne

A single small craft missile is 0.042 tonnes or 12 missiles per 0.5 tonnes.

SC Missiles are usually deployed from an enclosed bay, particularly if the small craft is designed to enter a planetary atmosphere. Multiple missile bays may be installed if the hull size allows for such, with the total number of missiles carried per bay and the space required for that number noted on the design.

For example, a ten-tonne space superiority fighter carries twenty-four missiles in a single bay. Total space requirement is 1 tonne for the single SCW allowed.

All fighters carrying small craft missiles will generally carry a mix of offensive anti-fighter and defensive AMSD missiles, varying the load-out according to mission requirements.

SC Missile Type	TL	Damage to Ships	Damage to Small Craft	Cost per 12 missiles (Cr)
Anti-Fighter (basic)	8	1d6	2d6	12,000
Anti-Fighter (nuclear)	8	2d6+ crew hit	3d6+ crew hit	30,000
Long Range Anti-Fighter	10	1d6-1	2d6-2	20,000
Long Range Anti-Fighter (Nuclear) ¹	10	2d6+ crew hit	3d6+ crew hit	45,000
Anti-Missile Sand Defense ²	8	N/A	1d6-3	6,000

¹ double the size of standard missiles

² AMSD are similar to sandcaster canisters

Though the thrust characteristics of an SC Missile remains the same as a ship class missile the range is reduced. This reflects the smaller missile size and the need to balance warhead and fuel for the missile drive. Refer to the table below.

SC Missile Type	Maximum Range	Duration in Turns
Anti-Fighter (basic)	Medium	4
Anti-Fighter (nuclear)	Medium	4
Long Range Anti-Fighter	Long	3
Long Range Anti-Fighter (Nuclear)	Long	3
Anti-Missile Sand Defense	Short	-

Ship class missile range tables can be found on page 181.

For example, a long-range anti-fighter missile has a maximum range of long, achieving that range in one turn. If the target is missed, then the missile has 2 more turns to re-acquire and hit the target.

SC Rapid Fire Railguns

More powerful than a vehicle mounted 35mm railgun, but smaller than a railgun mounted on spacecraft, these 30mm weapons can achieve a high rate of fire at close range targets. They are an ideal “knife fighting” fighter weapon.

Firing 20 projectile “bursts” per shot, the target’s armor is chipped away until they damage or destroy vital interior components. Each “burst” is considered as one damage roll.

An SC Railgun requires an allocation of 0.5 tonnes and costs 1MCr. Projectiles for the railgun require a further allocation of 0.05 tonnes per one thousand rounds.

Type	TL	Damage to Ships	Damage to Small Craft	Cost per 1000 projectiles (Cr)
Basic Kinetic Kill	11	1d6-3	1d6	5,000
Penetrator	11	1d6+1	2d6	8,000

SC Lasers (beam and pulse)

Small craft lasers are scaled down and less powerful versions of the turret mount lasers carried by spaceships. They are still however very effective weapons.

Type	TL	Optimum Range	Damage to Ships	Damage to Small Craft	Cost (MCr)
Pulse Laser	9	Close	1d6-3	1d6	0.4
Beam Laser	9	Short	1d6+2	2d6	0.75

SC Particle Beams

A small craft particle beam is the most powerful direct fire weapon available for installation in a small craft. Nicknamed “peebeeps” by fighter pilots, the damage inflicted by a hit from these weapons (even to a smaller starship) is considerable.

Power requirements for this weapon to be used effectively are significantly higher than an SC Laser and require the use of two SC weapon mounts or the use of one ship class weapon mount allowed for that size small craft hull.

An SC Particle Beam requires an allocation of one tonne and costs 5MCr.

Type	TL	Optimum Range	Damage to Ships	Damage to Small Craft
Particle Beam	10	Short	2d6-3	3d6-2
Particle Beam	12	Medium	2d6-3	3d6

Weapon Range Band Comparison

The table below compares the differing range bands for space combat and anti-personnel (vehicle) combat. Understanding the different range bands is important to be able to compare the ranges of differing weapon systems able to be installed into small craft.

Space		Anti-Personnel (Vehicle)		
Range Band	Distance (km)	Range Band	Distance (km)	Distance (m)
Adjacent	< 1	Close	0.0015 – 0.003	1.5 – 3
Close	1 -10	Short	0.003 – 0.012	3 - 12
Short	10 - 1250	Medium	0.012 – 0.050	12 - 50
Medium	1250 – 10,000	Long	0.050 – 0.5	50 - 500
Long	10,000 – 25,000	Distant	0.5 - 5	500 – 5,000
Very Long	25,000 – 50,000	Very Distant	5 - 25	5,000 – 25,000
Distant	50,000+	Extreme	25 - 50	25,000 – 50,000
		Continental	50 - 500	50,000 – 500,000
		Orbital	501+	501,000+

For Example, a fighter fires one of its light AA missiles (page 78 of the Cepheus Engine Vehicle Design Guide) at an enemy fighter at short range which the referee determines to be about 20km. The light AA missile has a maximum range of Very Distant. By consulting the table above, it can be determined that range band is 5 – 25km. For space combat however, that equates to between Close and Short. So the Light AA missile is deemed to be in range.

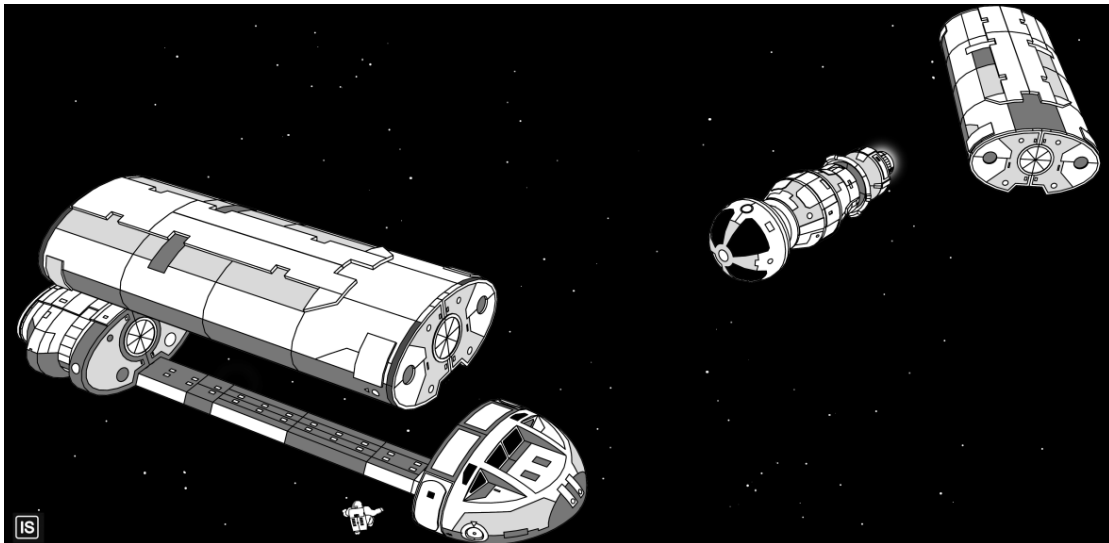


Crew

The minimum number of crew for a small craft depends on its size.

Tonnage	Minimum Crew
10 - 50	1
60 -100	2

A small craft may carry extra crew such as sensor operators, cargo masters, navigators or stewards depending on its role or as required. If more than one ship-weapon is installed in a small craft, then a gunner will be required. In addition, if the small craft has more than two anti-personnel weapons installed an additional gunner will be required for those weapons.



Design example – Armament, Crew and Cargo

A 30 tonne hull allows for one ship weapon and four anti-personnel mounts. The client has requested a single ship-weapon class beam laser and no anti-personnel weapons.

Fire control for the single fixed mount = $1 \times 1dT = 1dT$ costing 1.1MCr.

Weapons:

1 x beam laser = 1MCr.

Crew: 2

Cargo: 3dT

Armament, Crew and Cargo: Allocation = 4dT, Cost = 2.1MCr.

Design Example - SB/U-22-11 Ship's Boat

The thirty-tonne ship's boat is configured primarily for the utility role. Interior cabin space has been configured to allow transport of fourteen passengers and space for 3dT of cargo, externally accessible via a large cargo door.

A single fixed mount beam laser provides the boat with offensive/defensive capability as required. The beam laser can be removed from its mount by small craft maintenance crew to free up 1dT for two extra passengers.

Hull and Armor

Type			Tonnes	Price (MCr)
Hull	30 Tonnes Code s3	Hull 0	30	1.4
	Streamlined	Structure 1		
Armor	Crystaliron x1	4 points	1.5	0.3
Hull and Armor Total			1.5	1.7

Engineering

Type			Tonnes	Price (MCr)
Maneuver Drive	Type sJ	Thrust 6	4.5	10.0
Power Plant	Type sJ	Power 6	3.6	7.0
Fuel	Powerplant	2 weeks of operation	2	
Engineering Total			11.1	17.0

Command

Type			Tonnes	Price (MCr)
Bridge	Control Cabin	Crew Positions 2x	6.0	0.15
Computer	Model 1	Rating 5		0.03
Electronics	Standard	DM -4		
Command Total			7.5	0.2

Armament

Type			Tonnes	Price (MCr)
Weapons	Anti-Ship			
	Fixed Mount	Beam Laser	1	1.1
Armament Total			1	1.1

Crew, Passengers, and Internal Components

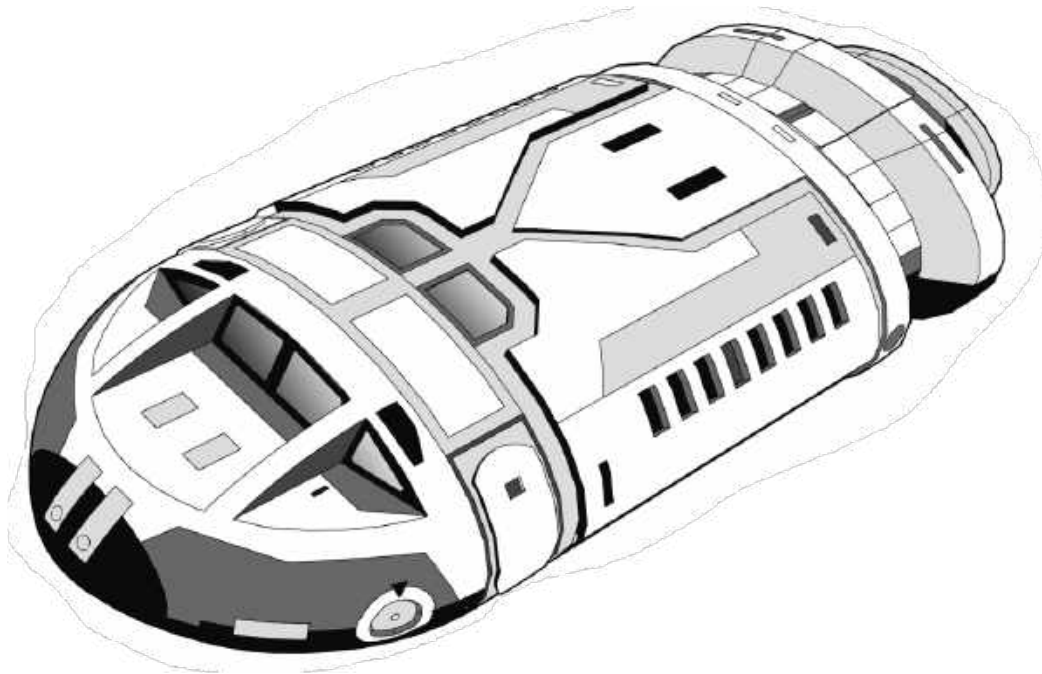
Type			Tonnes	Price (MCr)
Crew	2			
Passengers	12	Acceleration Seats 12x	6	0.36
	Airlock		1	0.2
Cargo	3 tonnes		3	
Accommodation Total			10	0.6

Software

Type		Rating	Price (MCr)
Software	Maneuver		
	Library		
Software Total			

Total

Type		Tonnes	Price (MCr)
Total Tonnage and Cost		30	20.6



Drones

It is possible to equip small craft as drones. At lower technology levels this is little more than making the craft remote control. However, at higher technology levels it is possible to provide the drone with a true autonomous capability. Such autonomous craft are typically not as skilled as their flesh and blood equivalents, but they do provide smaller system defense forces with the option of deploying more combat small craft. Remote operation mode is sensitive to electronic warfare and if within short range of a vessel, that vessel may use electronic warfare, (see *Clement Sector* pages 417) as if the drone was a smart missile to temporarily jam transmissions between the mother ship and the drone.

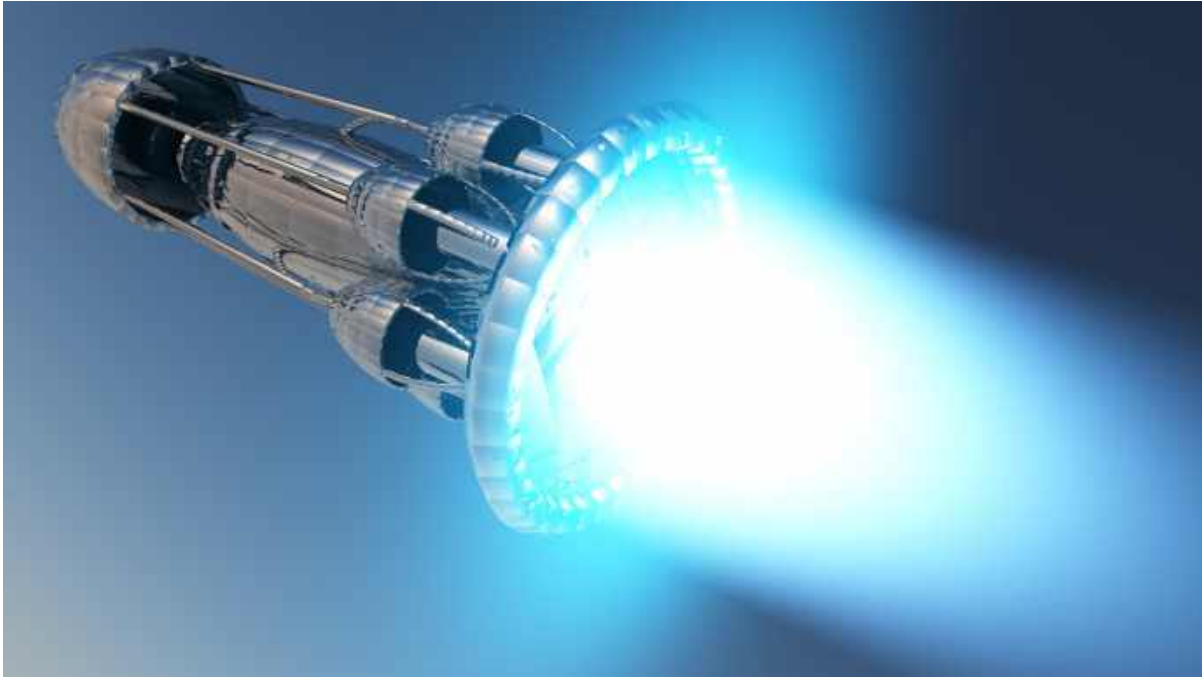
A drone command unit takes up 1.5 tonnes per required crew equivalent and includes a basic electronics suite.

TL	Functionality	Cost (MCr)
8	Remote Operation (non – combat) only	0.5
9	Remote Operation	2
10	Autonomous Mode (non-combat only) or remote operation	5
11	Autonomous Mode with Characteristic 5, skill level 1 or remote operation	7
12	Autonomous Mode with Characteristic 7, skill level 2 or remote operation	10

Small craft drones operating in autonomous mode are effectively robots with a range of specialist intellect and expert programs (see *Clement Sector* pages 338). The characteristics and skills of an autonomous mode drone will depend on its tech level, noting that all skills requiring physical characteristics used Intelligence instead.

TL	Characteristics	Skills
11	Intelligence 7 (+0) Education 9 (+1)	Intellect/2, Expert Pilot/2 and 2 Expert/2 (from astrogation, comms, mechanic, electronics and sensors)
12	Intelligence 8 (+0) Education 10 (+1)	Intellect/3 Expert Pilot/3, 1 Expert/3 and 2 Expert/2 (from astrogation, comms, mechanic, electronics, sensors, and gunnery)





Module 3 – Pre-Gravitic Drive Spacecraft

The following is a module to add pre-gravitic spacecraft to the spacecraft design sequences presented in this supplement. It can also be used with Cepheus Engine: Spaceship Design Guide.

“There is something both exciting and awe inspiring being at the front end of a two-hundred-meter-long plume of star hot plasma. It is as if one of man’s creations is challenging space itself to dare hold us back.” - Captain Christopher Blankenship USSN, CO USS Shannon (training ship), 2326 (standard)

The Reaction Drive

Prior to the discovery of a true reactionless gravitic drive, space faring civilizations rely on a succession of increasingly more sophisticated and efficient reaction drives to provide propulsion for spaceships and eventually, starships.

A reaction drive operates by simply ejecting matter rearwards of the spaceship at high velocity. Different types of drives do this in different ways, but all require on-board supplies of reaction mass to be used to propel the spacecraft.

The Balkfus Plateau

The general term used for the period of stagnation experienced by a society once a working theory for gravitic drives is discovered and the practical application of that theory technologically. This period could be as much as two hundred years or as little as five. Some civilizations either never discover the theory or are unable to construct a practical gravitic device.

Tomescu Balkfus was a discredited early 22nd century technology writer of Romanian descent who aggressively pushed his theories about space drive technology within scientific and enthusiast communities.

Reaction drives are generally operated at low thrust levels, even if the drive is capable of higher acceleration due to the need to carry large amounts of reaction mass. Higher acceleration can be used for short periods only or when the ship's captain knows they have a supply of replacement reaction mass at the end of the journey.

Reaction drives generally fall into several common categories, which are listed below. Each use differing methods to create thrust for the spacecraft they are installed in.

Liquid Fuel Rocket Engines

Liquid fuel reaction drives use vast quantities of internally combusted chemical propellant, usually liquid oxygen. This superheated gas is allowed to escape through a high-expansion ratio nozzle. The effect of the nozzle is to dramatically accelerate the mass, converting most of the thermal energy into kinetic energy. This then provides the high thrust needed by a rocket to overcome gravity and place a payload into orbit. The payload might be cargo for a space station, a satellite or a longer ranged spacecraft.

Solid fuel versions are also available, providing a "one use boost" for rockets climbing into orbit.

Though extremely inefficient, these are the first successful reaction drives for spaceships and appear in primitive form at TL5.

Electromagnetic and Plasma Drives

Ion drive

Instead of using chemical combustion to accelerate the reaction mass to high speeds, an electromagnetic or ion drive uses electrostatic or electromagnetic forces to accelerate a stream of ions rearwards. Such an engine typically uses electric power provided by a fission or fusion power plant, first to ionize atoms, and then to create a voltage gradient to accelerate the ions to high exhaust velocities.

Ion drives provide very low thrust compared to chemical rockets, but at the same time are vastly more fuel efficient.

Plasma Drives

The Variable Specific Impulse Magnetoplasma Rocket (VASIMR) uses powerful microwaves to heat its hydrogen fuel into a plasma state, and manipulates it using three powerful superconducting magnets, which further ionize and heat the plasma to extremely high temperatures as it flows through. The plasma exhaust can be shaped and controlled by variable magnetic fields to provide

more efficient thrust. By varying power used to heating and the amount of propellant provided for generating plasma VASIMR can generate low to high thrust as needed.

Since the fuel used is kept at cryogenic temperatures, it can be used to help cool the drive as a whole but also to keep the superconducting materials within the magnets at proper operating temperature, as well.

As a bonus, the powerful magnetic fields of the engine can act as a supplementary radiation shield during travel.

VASIMR drives generate higher thrust than Ion drives and thus are better suited for long range space travel.

Fusion Drives

One of the main drawbacks of a pure fusion drive is that the fusion reaction always produces radiation, requiring heavy shielding for the crew. The plasma exhaust is also highly radioactive which makes their use on or around inhabited worlds problematic. Typically, the fusion drive would be shut down on approach to inhabited worlds or settlements and the ship would coast to its destination.

Fusion drives can be either Deuterium-tritium, which provides much more energy, higher thrust or deuterium-helium3 which produces far less radiation but less thrust and energy. Of the two, DHe3 fuel is preferred.

Further development of the first crude fusion drives created hybrid fusion-plasma models that could be scaled down in output, reducing radiation to very low levels. Scaling down output though reduced thrust and ship velocity, so the plasma drive was only used where necessary.

Fusion pulse (direct fusion drive)

The fusion pulse drive is one of the first types of fusion drives used for propelling spaceships. It uses magnetism to compress lithium or aluminum metal rings around a deuterium-tritium fuel pellet to initiate fusion. The converging rings merge to form a shell that ignites the fusion, but only for a few microseconds. Even though the compression time is very short, enough energy is released from the fusion reactions to quickly heat and ionize the shell. This super-heated, ionized metal is ejected out of the rocket nozzle at a high velocity. This process is repeated every minute or so, propelling the spacecraft.

Fusion Plasma

A fusion plasma drive heats or otherwise energizes deuterium-helium3 until fusion occurs. The energy created by the fusion reaction creates superhot, high velocity plasma which is vented through an opening in the magnetic confinement into a secondary "afterburner" chamber where it mixes with colder plasma or gas. The mixing of the hot fusion plasma with the secondary plasma

results in a plasma that is denser and colder. This is then allowed to escape into space, providing even more thrust at a lower exhaust velocity for the same power.

A combined cycle fusion plasma drive has a dynamically controlled thrust system, where the magnetic fields and/or catalyzing electron beam are easily variable so the same engine can function as both plasma and a fusion drive of varying outputs as required.

This can prove very advantageous in craft designed to operate both within a planet's atmosphere as well as in deep space, as the vessel can use the plasma rocket mode for travel on or near planets and not have to worry about radioactive exhaust threatening a biosphere or population. Once away from the planet, however, it can kick up the power to fusion mode for rapid deep space travel.

Anti-Matter Plasma (AMP) Drive

Considered to be the ultimate non-gravitic drive, but also the most expensive, the AM plasma drive operates on the principle of using matter-antimatter annihilation to create super-heated plasma by fusing either deuterium-tritium or deuterium-helium3 reaction mass fired through a "trap" containing the anti-protons. This superheated plasma is then expelled at very high velocity for thrust. After each such "burn" the antiprotons in the magnetic bottle are allowed to reset back to their original configuration, minus about half a percent of their original mass, which was used up in the burn cycle annihilations. After every fifty to one hundred "burns", new antiprotons are injected into the magnetic bottle to reload the trap. Burn Cycles per minute number in the hundreds or thousands.

Reaction Drive Table

Type	Modifiers*		Fuel Use	Maximum	Minimum	Tech
	Size	Cost	% (Fc)	Thrust (g) ²	Drive Size	Level
Liquid Chemical Fuel	x1	x1	25	6	F	5
Ion Drive	x1.5	x1.8	0.0025	0.05	sA	7
VASIMR	x2	x2	0.025	0.3	sA	8
Fusion Pulse	x1.3	x1.5	0.8	3	A	8
Fusion Plasma	x1	x1	1	3	A	8
AMP Drive	x1.5	x4	0.8	4	S	10
Aerorocket ¹	x0.8	x0.8	2	4	sA	8
Scrapulse ¹	x0.8	x1	1.5	6	sA	9

* Apply these modifiers to values in the standard drive tables, pages 37-39

¹ Small craft drives only. Apply these modifiers to values in the small craft drive tables, pages 132-133

² This is the maximum thrust the selected reaction drive can attain.

Reaction drive fuel requirements

Req = Fc(ship displacement) x maximum thrust x hours of maximum thrust required

Calculation Example

A 500dT sloop with a TL10 AMP Drive with a 3G rating, providing constant maximum thrust for a period of twelve hours.

$0.8/100(500)3 \times 12 = 144dT$ reaction mass required

So, the sloop can accelerate continuously for a maximum of twelve hours at 3G. If it did that though, it would run out of reaction mass at the end of that time.

Most ships with reaction drives either accelerate at a lower thrust or accelerate and coast, conserving reaction mass.

Reaction mass fuel must be allocated separately from Zimm Drive fuel and power plant fuel. For instance, chemical rockets use liquid oxygen, ion and VASIMR drives use argon or hydrogen while fusion hybrid and AMP drives use deuterium-tritium or preferably deuterium-helium3.

Reaction drive ships cannot dive for fuel within gas giant atmospheres or planetary water bodies. However, those ships equipped with on-board fuel processors can extract fuel from supplied water or gathered ice.

For reaction drive ships on extended duration missions, an accompanying tanker is an automatic consideration.

Power Plants

Power plants for reaction drive ships are the same for those using gravitic drives. Most common are highly reliable and efficient fusion power plants, but older fission reactors and chemical power plants are available also. The two most commonly used drives are listed below.

- Fission
- Fusion

See Page 35 for power plant design tables.

Reaction Drive Heat Dissipation

Ejecting plasma at star temperatures rearwards to provide thrust creates large amounts of waste heat that needs to be dissipated in order to avoid damage to the ships drives, structure, and crew. Fortunately, the very nature of space provides a nearly perfect insulator. Hull mounted radiators can dissipate waste heat from the reaction drives quickly and efficiently.

Unlike gravitic drive ships, reaction drive ships must install radiators. A radiator array requires 10% of the combined total of drive and power plant displacement at a cost of 50,000Cr per dT of radiator array.

Reaction Mass Tanks and Shielding

Reaction mass tanks can provide a cheap and effective method of shielding the crew from harmful cosmic radiation and particles of matter that could otherwise puncture the habitat sections of the ship. Rotating habitat sections can be sited behind, in the “shadow” of the reaction mass tank.

It is quite common to see large and small reaction drive ships with large bow “mushroom cap” reaction mass tanks.

For a warship, the reaction mass tanks located in the bow also provide an excellent shield against incoming enemy fire.

Magnetic Shielding

Normally a ship’s hull equipped with radiation shielding (see page 31) will provide very good protection from the hazards of space travel, but there still can be risk to crew and passengers depending on the zone of space through which the ship is traveling.

At a sufficiently high technology, a reaction drive spacecraft’s crew and passenger areas can be protected by a shaped magnetic field of sufficient strength projected outside the hull that is designed to deflect harmful cosmic radiation and particles of matter.

Starting at TL9, a magnetic field generator costs 1MCr per 20dT of space it is to protect. The generator will take up 0.2dT of the total space protected.

Improved Acceleration Protection

For spaceships undertaking high continuous thrust for any length of time, it is essential to ensure the crew and passengers are protected from G-forces for the duration of the high acceleration.

For spaceships and small craft that can exceed 1.5G, installation of some form of acceleration protection is mandatory.

There are several methods to provide such protection, but the simplest is to provide acceleration couches. These are considered part of the cost of a spaceship and add 5% to the cost of any bridge type and stateroom.

Hull Type Limitations

The following design criteria must be noted for any of the hull types selected during design of any reaction drive craft.

Distributed hulls

Cannot land on any planetary surface or enter any atmosphere type. Vessels of this hull type cannot use axial rotation to produce spin gravity.

Standard Hulls

Spacecraft of this hull type can land and leave a planet with an atmosphere but cannot maneuver within that atmosphere. Any type of spin gravity is available.

Streamlined Hulls

Spacecraft of this hull type can land, leave, and maneuver in any atmosphere. The only type of spin habitat available for this hull type are extendable spin pods.





Alternative Reaction drives

External Pulsed Plasma Propulsion (EPPP) or Orion Drives

Also known as Orion Drives, EPPP drives are an early alternative to chemical fuel rocket propulsion using controlled nuclear detonations to provide constant thrust. Small nuclear pulse pellets, acting as either fission or fusion shaped charges, are fired from a launcher or “gun” and detonated at a specific distance to the rear of the vessel so that the force of the resulting plasma jet pushes against a pusher plate. The force acting on the plate caused by the pellet’s nuclear detonation and the resulting heat and velocity of the plasma jet provides thrust for the space vessel.

The detonation point is positioned such that the impulse plasma jet cone is the exact diameter of the pusher plate. If the plasma jet was wider than the pusher plate, then generated thrust would be less efficient and there would be an increased risk the plate would be destroyed by the impulse.

The pulses are so brief that there is no appreciable irradiation of the rear of the space vessels hull and structure which allows crew to exit the spacecraft as needed to undertake maintenance work shortly after the pulse units stop detonating. Radiation is also not a problem for the crew, though habitation and command sections must be within the forward section of the vessel.

The small yield nuclear pellets are fired by the “gun” at a base rate of approximately one per second (pulse) to maintain a minimum of one gravity of thrust. Larger vessels require a higher yield pellet to provide desired thrust. Like all reaction drive vessels, once desired thrust is achieved the vessel would then cease accelerating until turnover to decelerate to destination arrival.

Directly forward and attached to the pusher plate is the shock absorber mechanism which is required to absorb impulse shock that could damage the superstructure of the ship and kill any crew. Smaller pulse pellets fired at a higher pulse rate ensure less impulse shock.

Propellant magazines are required to store the pulse pellets. These are located forward of the shock absorber mechanism.

There are both fission and fusion EPPP drives available. Fusion EPPP drives use smaller and more efficient pulse pellets providing greater thrust duration for the same magazine capacity than Fission EPPP drives or smaller magazine capacity for the same thrust value. Pulse pellet types are not interchangeable between drive types.

Though EPPP drives are capable of providing up to ten gravities of thrust, they are capped at a more modest four gravities. More suited to larger sized space vessels, an EPPP drive powered vessel cannot be less than 1000 tonnes.

External Pulsed Plasma Propulsion Drive Table

Type	Modifiers*		Fuel Use	Maximum	Tech Level
	Size ¹	Cost	% (Fc) ³	Thrust (g) ²	
Fission	x3	x0.5	1.8	4	7
Fusion	x2.5	x0.8	1.4	4	8

* Apply these modifiers to values in the standard drive tables on pages 37-39

¹ Drive size includes the pusher plate size allocation.

² This is the maximum thrust the selected EPPP drive is capable of attaining.

³ Fuel Use % (Fc) reflects the size and yield strength of pulse pellets used.

The impulse shock absorber mechanism for an EPPP drive is determined by multiplying the hull size by 2% at a cost of 0.2MCr per tonne.

The pulse pellet magazine size is determined by EPPP drive type and duration of the expected continuous maximum acceleration as per below. The required allocation includes the magazines feeder mechanism that loading pellets into the pellet gun.

Req = Fc(ship displacement) x maximum thrust x hours of maximum thrust required

Calculation Example

A 10,000dT ice hauler with a TL7 EPPP Fission Drive with a 1G rating, providing constant maximum thrust for a period of four hours.

1.8/100(10,000)2 x 4 = 1440dT pulse pellet magazine size required.

So, the ice hauler has enough pulse pellet magazine capacity to enable it to accelerate continuously for a maximum of four hours at 2G. If it did that though, it would have an empty magazine at the end of that time and would not be able to decelerate.

Generally, EPPP powered vessels have restrictions imposed to ensure they do not approach closer than high orbit. These restrictions will vary from system to system. They cannot be equipped with a Zimm Drive.

Electromagnetic Drives (EM Drive)

The EM Drive (or RF resonant cavity thruster) origins began in the early twenty first century as a proposal for a normal space drive that required no reaction mass. Such designs work by having a magnetron push microwave photons into a closed truncated cone which then acts against the short end of the cone propelling the vessel forward. The thrust produced is quite low with initial test drives providing a performance like early ion drives.

For decades scientists could not understand how any thrust was generated at all as a reactionless drive broke several laws of physics and the law of the conservation of momentum. As the understanding of quantum theory grew it was realized that the EM Drives created thrust by quantum means and further refinement of the design allowed for much higher thrust ratings to be achieved. The EM Drive was eventually marketed by several companies as an option for space vessel propulsion.

Only able to function well in a vacuum, the EM Drive has a maximum thrust rating of two gravities. Competing with reaction drives that could produce much higher thrust, the EM drive was never a financial success but was a popular normal space drive for exploration and survey craft during the early waves of interstellar expansion.

To select an EM drive for use in a space vessel, choose an appropriate drive from the drive potential table (found on page 39) and apply the following modifiers. The EM Drive requires no fuel.

EM Drive Modifier Table

Drive Size	Drive Cost	Available Thrust
x0.8	x2	x0.25

Plasma Propulsion Unit (PPU)

A much more efficient and refined version of the fusion plasma drive, the plasma propulsion unit (PPU) provides greater thrust for a more sustained period. Reaction mass, now in the form of fuel cells, is also reduced by a considerable degree.

This drive could be used as a mature normal space drive design prior to the discovery of a true gravitic drive or the main drive for spacecraft used by a mature star faring civilization that has gravitic technology but not that technology for propulsion. Please see page 34 for Artificial Gravity and Inertial Compensator details.

Plasma Propulsion Unit Modifier Table

Type	Modifiers*		Maximum Thrust (g) ²	Tech Level
	Size	Cost		
PPU Type 1	x1.6	x1.6	4	10
PPU Type 2	x1.2	x1.4	4	11
PPU Type s2 ¹	x1.2	x1.5	8	11
PPU Type 3	x1.1	x1.2	6	12

* Apply these modifiers to values in the standard drive tables on pages 37-39

¹ Small Craft drive only. See small craft drive tables on pages 132-133

² This is the maximum thrust the selected reaction drive can attain.

Minimum fuel cell requirements for a selected PPU drive will be four times the PPU drive tonnage. This will provide the spacecraft with enough fuel cell capacity for ninety-six standard hours (4 days) *continuous* acceleration at the maximum rated thrust of the drive.

Of course, the spacecraft, like other reaction drive powered vessels, will spend most travel time coasting at a given velocity gained by a short period of active thrust. However, it is common for warships and other specialist vessels to carry enough fuel cells to provide for greater duration.

PPU drive fuel cells can only be refueled at specialist facilities normally located at Starports and refueling depots. While recycled PPU drive fuel cells can be found for purchase, these are less expensive but reduce any continuous thrust duration times by 20%.

Standard PPU drive fuel cells suitable for spacecraft and small craft cost 500Cr per tonne with the total cost being rounded up to the nearest tonne required.

A cheaper recycled fuel cell will cost between 20-25% less. A PPU drive fuel cell is not compatible with a power plant fuel cell (see page 41) if that option is being used.

Artificial Gravity

From the very beginning of space flight, it was known that long-term exposure to zero gravity (micro gravity) causes debilitating physical conditions such as bone density loss and muscle loss. Practical experience and tests conducted in those early days when space travel was limited to orbital flights revealed that there needed to be some form of artificial gravity coupled with stringent exercise regimes and supplementary medical treatment during long term space missions.

Some form of artificial gravity for long-term flights is essential on psychological grounds also, allowing a ship's crew to eat, sleep and perform a myriad of daily functions in relative comfort and ease.

For every four-week period of continuous micro gravity exposure there will be a one point strength and endurance characteristic loss that will require 1d6 weeks of recovery in a one standard gravity environment.

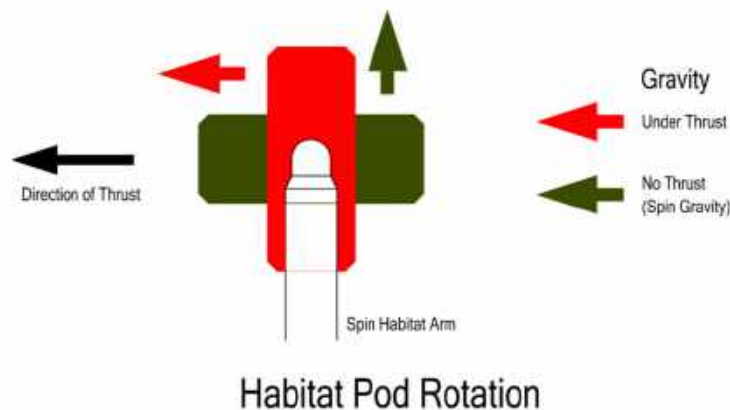
The two main methods of producing artificial gravity are:

Thrust

Producing "rear is down" gravity

A spaceship under acceleration will produce thrust gravity. In this instance the ship's internal layout will need to be perpendicular to the axis of the ship or ninety degrees to the line of flight.

Centrifugal rotation



Producing "out is down" gravity

For any type of method using centrifugal rotation to produce gravity, the internal layout must be aligned so that decks face inward towards to center of the rotation arc. In other words, the deck is the outer edge of the path created by any spin. An appropriate radius and rotation must be designed to avoid occupants becoming incapacitated from different forces pulling at their head and their feet.

For a space station or space habitat, centrifugal rotation is the only form of artificial gravity that can be used effectively. Gravity acts towards the center of rotation.

Ships tend to use both methods of producing gravity with deck arrangements to suit zero gravity, thrust gravity and gravity produced by centrifugal rotation. The preferred and most practical artificial gravity arrangement for ships that are not under thrust are spin habitat pods. By allowing the pods to rotate to an appropriate angle when the ship is under thrust, complicated internal deck rotations can be avoided.

A ship cannot use any type of spin gravity under thrust as the resulting combined forces of linear acceleration and centrifugal rotation will cause the ship to tumble, often with catastrophic results.

If a ship has been designed to be able to land, then the retracted pods can further be able to rotate so the deck is "down". These sorts of complicated arrangements are rare as pre-gravitic drive space craft big enough to use spin gravity tend to be pure space craft, relying on small craft for ferrying passengers and crew.

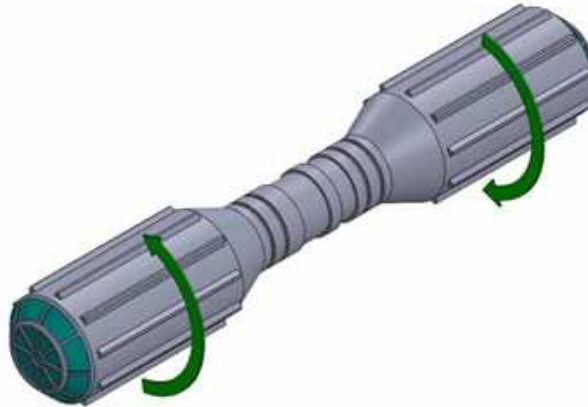
Spin Habitat types

Axial Rotation

Probably the simplest and most inexpensive way to provide spin gravity is to rotate the ship along its long axis. The internal deck arrangements must be changed every time the ship changes from spin gravity to thrust (out is down to rear is down). This can either be achieved by simply physically rearranging the decks and reattaching any furniture (though this would add complications rearranging control consoles), using gimbal arrangements to rotate the interior decks themselves or a combination of both.

The zero-gravity central section of the hull along the long axis is used for cargo, low maintenance machinery, fuel, and small craft hangar space. Rotation (and counter rotation) can be achieved using rotation thrusters mounted along the exterior of the hull.

O'Neill Cylinder



An O'Neill Cylinder consists of two axially rotating cylinders either side of a central core. The cylinders rotate in opposite directions to cancel out any gyroscopic effects. Gravity along the center of each cylinder is negligible allowing for recreation facilities, storage, and engineering areas.

Used as space habitats, O'Neill Cylinders can be exceptionally large in both length and diameter allowing for a lower rotation to achieve any desired gravity.

Smaller versions can also be used on spacecraft set at right angles to the main hull. Each cylinder can be rotated when spin has ceased to allow interior decks to be moved into the appropriate alignment when the ship is under thrust and when spin rotation recommences.

Toroid Habitat

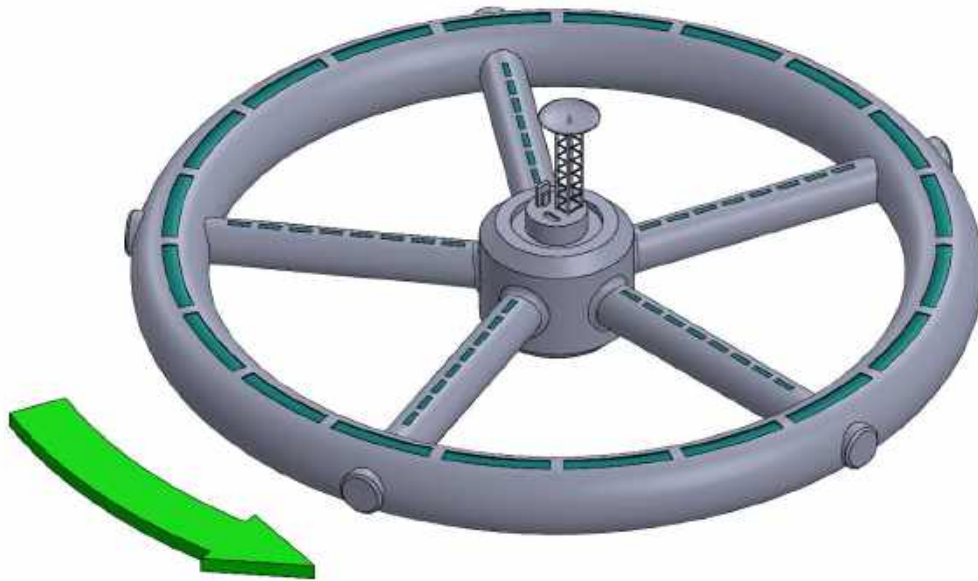
More commonly used for space habitats, a toroid habitat can either rotate around a non-rotating core structure such as a ship's main hull or rotate fully on its own. At the central core or rotation point of the toroid, gravity is effectively zero.

In the case of space stations, the zero-gravity central core usually contains docking bays and engineering areas.

It is not uncommon, however, that docking arms extend radially outward of the toroid allowing crews and passengers to exit/embark docked ships in the comfort of gravity. Maneuvering to dock to a docking arm moving with the rotation of the toroid would require a ship to match that movement exactly.

Like O'Neill Cylinders, toroid habitats can have very large diameters, which allows a much lower rotation rate to achieve any desired gravity.

When a toroid habitat is used to provide spin gravity for a ship, a gimbal arrangement allows interior decks to be rotated into the appropriate alignment when the ship is under thrust or if spin rotation is being used.

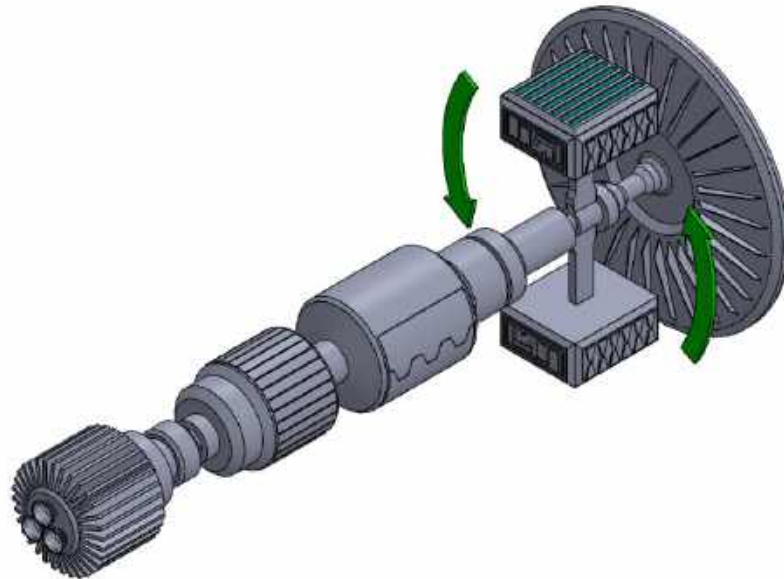


Spin Habitat Pods

A spin habitat pod system consists of a pair of arms with the habitat pod at the end of each arm. The pod array can be as simple as two arms or have as many as four arms. Some designs have two separate two pod arrays that rotate in different directions to counteract torque which could affect the ships flight. A two pod array is most common in service.

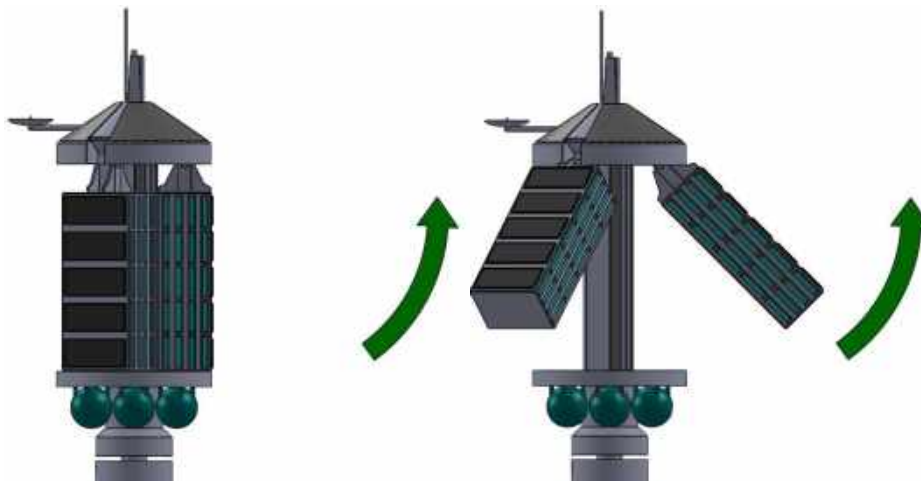
The pods can be fixed so that the decks are aligned "out" and when the ship is in thrust the internal decks can sectionally rotate so they are "down".

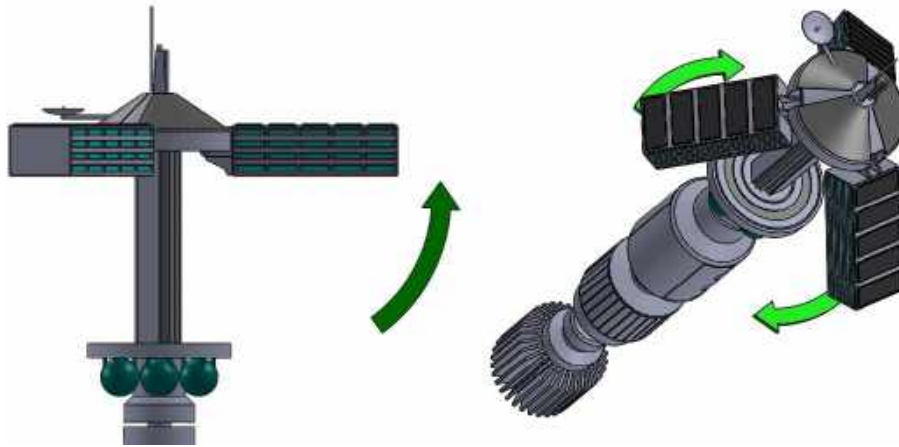
A more efficient design is to allow the pods to rotate to align themselves when the ship is under thrust or if spin rotation is being used. If the pods are to rotate, then the multipliers for Extendable Spin Habitat Pods are to be used.



Extendable Spin Habitat Pods

For ships able to achieve higher thrust or for military vessels, the ability for habitat pods to retract against the main hull has many advantages. In combat, the pods and the rotation arms are vulnerable to damage and offer up a bigger target signature. For those ships that are streamlined to land on a planetary surface with an atmosphere, extendable habitat pods must be installed. This increases cost and volume of the pod array.





Design of a Spin Habitat

To design a spin habitat, first sum up all the sizes of all the components required to be under gravity. Then select the type of spin habitat required. The tables below provide the appropriate modifiers to calculate the cost and displacement of the spin habitat type chosen.

Spin Habitat Table

Spin Habitat Types	Requirement per dT	Base Cost per dT
Axial Rotation	0.00	x0.03
O'Neill Cylinder	0.10	x0.06
Toroid Habitat	0.10	x0.08
Spin Pods	0.20	x0.08
Extendable Spin Pods	0.40	x0.12

Requirement is the allocation for spin habitat machinery (including flywheel contra-rotation machinery) per dT of the pod sizes. Cost is per dT of pod sizes.

Centrifugal Gravity Table (g)

Arm Radius (m)	Rotations Per Minute					Cost Multiplier	Size Multiplier
	6	5	4	3	2		
10	0.40	0.28	0.18	0.10		x1	x1
15	0.60	0.42	0.27	0.15		x1	x1
20	0.80	0.56	0.36	0.20		x1.1	x1.2
25	1.00	0.70	0.45	0.25	0.11	x1.2	x1.3
30		0.84	0.51	0.30	0.13	x1.2	x1.4
35		0.98	0.63	0.35	0.16	x1.3	x1.6
40		1.10	0.72	0.40	0.18	x1.3	x1.8
50			0.89	0.50	0.22	x1.5	x2
60			1.10	0.60	0.26	x1.5	x2.1
80				0.80	0.36	x1.7	x2.2
100				1.00	0.45	x2	x2.3

Calculation Example

*Allocating 100dT of hull (2 x50dT) as extendable pods requires spin machinery to be;
0.4 x 100 = 40dT machinery at a cost of 0.12 x 100 = 12MCr*

The arm radius is to be 25m with a rotation of 5RPM providing 0.7g in the pods

The cost multiplier is applied to the base cost of the spin habitat.

12 x 1.2 = 14.4MCr

The size multiplier is also applied to spin habitat size to reflect arm radius.

40dT (from above) x 1.3 = 52dT

Spin Gravity

Formula

$$g = \frac{R \times \left(\frac{\pi \times \text{rpm}}{30}\right)^2}{9.81}$$

Or

$$R = \frac{9.81g}{\left(\frac{\pi \times \text{rpm}}{30}\right)^2}$$

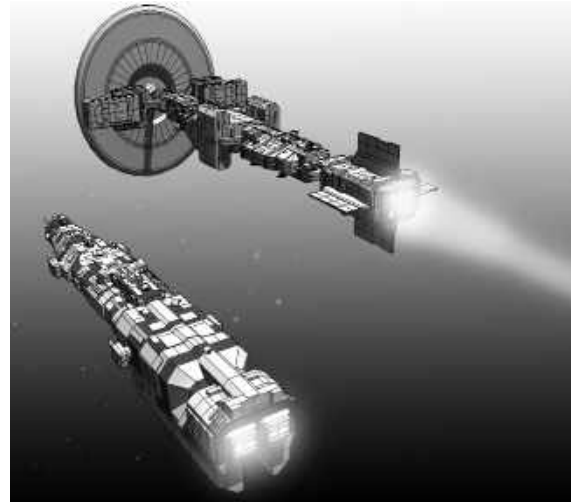
Where:

g = Generated gravity (Earth gravity = 1G or 9.81m²)

R = Arm radius (from center of rotation) in meters

$\pi \approx 3.14159$

rpm = Revolutions per minute





Small Craft

Small craft perform a myriad of duties and can usually operate in both space and atmosphere. For a large ship unable to enter planetary atmospheres, small craft, while not essential, can be important vehicles for crew and cargo transfers.

A small craft is defined as having a hull size under 100 tonnes and can be either streamlined or non-streamlined depending on the role it is designed to undertake. Streamlined hulls for small craft are further defined into three specific types, each having their own fuel consumption and hull type modifiers.

Hull Configuration

Standard

This is the standard aircraft design with hull and lift-generating wings that can be fixed or variable incidence (swept wings).

Lifting Body

These have no wings and generate lift by the shape of the hull. Lifting body designs are more resilient but are far less maneuverable in atmospheres.

Blended Lift Body

Using the best features of the standard and lifting body hull types, a blended lift body hull is very efficient but the most expensive.

Non-Streamlined

Small craft designed to operate only in space do not require streamlining. They usually have a simple Ion or VASMIR drives for thrust and the ability to land on airless bodies with very low gravity such as moons or asteroids.

Many types of non-streamlined small craft are a simple arrangement of control cabin, mission, and thruster modules.

Small Craft Drives

Small craft intended for use in atmosphere use either Aerorocket or Scrampulse drives. Both are hybrid drives that provide for atmospheric and space movement.

Aerorocket

Combining air breathing turbojet, high speed scramjet and rocket propulsion, an aerorocket drive allows a small craft to enter and leave atmosphere switching between liquid fuel rockets and turbo jets or vice versa. Aerorockets build on engine technology designed for use in hypersonic transport aircraft. Aerorocket drives appear at TL8.

Scrampulse

Essentially a refinement of aerorocket technology, the scrampulse replaces the liquid fuel rocket with a VASIMR plasma thrust drive. Appearing at TL9, scrampulse drives are more efficient but more expensive. See main reaction drives table for modifiers.

VTOL/STOL

Small craft designed to fly within atmospheres can either land like a conventional aircraft or use VTOL/STOL technologies. For a small craft to be able to take off and land vertically or to reduce landing and take-off lengths, the drives need to be modified to provide the ability.

This modification is most commonly provided by tilt nozzles or variable nacelles venting turbojet exhaust gases or plasma reaction mass.

Atmospheric Speed

The operational atmospheric speed of a standard hull small craft is rated at 1100km per 1G of rated thrust. Other hull types further modify that conversion as per the table below.

As a guide, a standard hull small craft cannot exceed 5500kph within atmosphere and a lifting body type hull cannot exceed 3000kph. A blended lifting body hull form, being more efficient, has a maximum allowable speed of 6500kph.

Small Craft Hull Types

Hull Type	Fuel Consumption Modifier	Hull Cost Modifier	Atmospheric Speed Modifier
Standard	x1	x1.1	x1
Lifting Body	x1.5	x1.3	x0.7
Blended Lifting Body	x1.2	x1.6	x1.6
Non-Streamlined	x1	x0.9	n/a

VTOL/STOL Drive Modifiers

Type	Drive Modifiers	
	Size	Cost
VTOL	x1	x1.1
STOL	x1.5	x1.3

Reaction Drive Missiles

Before the practical development of gravitic drives small enough to install into missiles in 2275, the solid fuel chemical drive was the only propulsion system available for use.

A solid fuel system balanced the need for high acceleration and missile size but at the cost of a smaller warhead and shorter range. Heavier missiles increased range and warhead size but were considerably larger than smaller missiles that could be fired from missile racks mounted in turrets and bays.

Missile racks are launchers for small anti-ship missiles. The damage of a missile depends on the type of missile used. Missile racks need ammunition – twelve missiles take up one tonne of space.

Pre-gravitic missiles are capable of thrust 8 but have a limited endurance of 30 minutes (5 turns) before they consume the solid propellant supply.

Range	Turns to Impact
Adjacent	-
Close	-
Short	1
Medium	2
Long	4
Very Long	-
Distant	-

Missile Types

Missile Type	TL	Damage	Cost per 12 missiles (Cr)
Basic	6	1d6	15,000
Jammer/Decoy	8	special	50,000
Long Range Missile	8	2d6-2	35,000
Kinetic Kill	8	2d6	30,000
Multi-Warhead	8	special	40,000
Nuclear	6	3d6 + crew hit	45,000
Ortillery	7	4d6	25,000

Basic missiles

Basic missiles get to make a single attack. This type of missile, armed with a small high explosive warhead, is freely available to civilian vessels to use for defense.

Decoy and Jammer Missiles

Packed full of electronic jammers and decoy hardware, jammer and decoy missiles are designed to overcome and confuse ship defense fire control computer sensors. They are typically fired along with a salvo of up to twenty missiles and are not available for civilian use. Attacks made with on a missile salvo which includes a jammer or decoy missile have a -3DM for point defense to hit.

Long Range Missile (LRM)

Long range missiles have a smaller warhead to allow them to carry more reaction mass. A long-range missile's range table is below.

Range	Turns to Impact
Adjacent	-
Close	-
Short	1
Medium	2
Long	4
Very Long	6
Distant	-

A LRM only deals 2d6-2 damage instead of 2d6, travels at thrust 9, costs 35,000Cr and has an endurance of 6 turns.

Kinetic Kill missiles (KKM)

Kinetic Kill missiles use kinetic energy generated by the missiles high speed impact to damage a target. This type of smart missile is used by naval vessels, and civilian vessel owners or captains will be prosecuted if they are found to be using them. A KKM has a smaller warhead allowing more space for more reaction mass and a more powerful drive to produce a thrust of 10, reducing turn to impact time by one turn.

Multi-warhead Missile (MWM)

Multi-warhead missiles carry a payload of four warheads, which separate at a pre-set distance from impact. Each warhead will travel to the target at the same speed as the missile at time of separation. The downside is that the larger payload slows the missile, so it takes longer to reach its target at long range.

Range	Turns to Impact
Adjacent	-
Close	-
Short	1
Medium	2
Long	5
Very Long	-
Distant	-

An MWM that hits its target deals 2d6 damage 1d6-2 times, travels at thrust 6, costs 40,000Cr and has an endurance of 5 turns.

Nuclear missiles

Nuclear missiles make a single attack as basic missiles but also inflict a radiation crew hit as well as a normal hit. Civilian ownership of nuclear weapons is strictly prohibited by various long-standing agreements by all civilized nations and independent planetary systems, agreements that pre-date any settlement in Clement Sector.

Ortillery Missile

Ortillery missiles are specially designed for planetary bombardment. They are too slow to be used as anti-ship weapons except at Close or Adjacent range. Attacks made with an Ortillery Missile have a -2DM to hit and Point Defense attacks against the torpedo have a +2DM.

Reaction Drive Torpedoes

Able to inflict tremendous destructive force against an enemy combatant, torpedoes are heavy 2.5dT anti-ship missiles with a thrust of 6. Like smart missiles, they can be defended against using standard anti-missile countermeasures. Torpedoes are purchased in two-shot loads of five tonnes each. A torpedo barrette can fire one torpedo per round. A torpedo has the same endurance as a missile.

Torpedoes cannot be used in atmosphere.

Torpedo Type	Torpedo Types		
	TL	Damage	Cost per Torpedo (MCr)
Nuclear	7	6d6	1.0
Nuclear Multi-Warhead	8	6d6	1.2
Bomb Pumped Laser	9	7d6	2.0

The TL in the table above indicates the lowest technological level of that type of missile.

Nuclear

A nuclear torpedo will deal 6D damage along with the radiation trait.

Bomb-Pumped Laser

The primary anti-ship torpedo, the bomb-pumped laser torpedo is a one-shot laser weapon. The torpedo contains a small nuclear device that is detonated prior to impact to charge a laser. The explosion destroys the torpedo, but also generates a powerful x-ray laser burst. The bomb-pumped laser is a normal laser attack but deals 7D damage. The basic roll to hit is as a missile but is defended against as a laser. Point defense can be used to attempt to kill the torpedo before it detonates but suffers a DM -2 due to the fact the bomb-pumped laser can be used in a stand-off role.

The Effect of Technology

Like other components of a spacecraft, reaction drives are also affected by technology level. For full details on how to apply technology effects, refer to page 116.



Module 4 – Zimm Drive Alternatives

Introduction

The Anderson and Felix Guide to Naval Architecture has been primarily written to enable referees and players to design space vessels for use within the Clement Sector setting.

The Zimm Drive, with its maximum transit range of two parsecs and capped starship size, has shaped the composition and makeup of Clement Sector. As changing that dynamic may upset this balance it is the only interstellar drive recommended for use within the setting.

For those who want to use this publication for another setting the following alternatives might be of some interest.

The Stardrive

Capable of allowing starships of up to 20,000 tonnes to cross up to four parsecs per week in a single transit, Stardrives can be fitted into vessels one hundred tonnes or larger. A Stardrive cannot operate within a one hundred diameter radius of any planetary body.

The Stardrive Cost and Potential Tables allow for Stardrive selection per vessel tonnage along with cost and space requirements. A starship must have a computer and correct software installed with the same rating or higher as the chosen drive rating to be able to use that drive. Stardrive software is also listed below.

Stardrive Rating	TL
1	9
2	11
3	12
4	13

Fuel Requirement

Like a Zimm Drive a Stardrive uses refined hydrogen for fuel. The required fuel used by a Stardrive for a single transit can be calculated by the following formula.

$$F = 0.1 \times H \times Sn$$

F = Fuel required in tonnes (dT)

H = Tonnage of hull (dT)

Sn = Stardrive rating

For example, a 400-tonne ship with a Stardrive rated for three parsecs would require $0.1 \times 400 \times 3 = 120$ dT Fuel.

Stardrive Cost Table

Code	Tonnes	MCr
A	10	10
B	15	20
C	20	30
D	25	40
E	30	50
F	35	60
G	40	70
H	45	80
J	50	90
K	65	100
L	60	110
M	65	120
N	70	130
P	75	140
Q	80	150
R	85	160
S	90	170
T	95	180
U	100	190
V	105	200
W	110	210
X	115	220
Y	120	230
Z	125	240



Stardrive Potential Table

Performance by Hull Volume

	100	200	300	400	500	600	700	800	900	1000	1200	1400	1600	1800	2000
A	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
B	2	2	1	1	-	-	-	-	-	-	-	-	-	-	-
C	3	3	2	1	1	1	-	-	-	-	-	-	-	-	-
D	4	4	2	2	1	1	1	1	-	-	-	-	-	-	-
E	4	4	3	2	2	1	1	1	1	1	-	-	-	-	-
F	-	4	4	3	2	2	1	1	1	1	1	-	-	-	-
G	-	-	4	3	2	2	2	2	1	1	1	1	-	-	-
H	-	-	-	4	3	2	2	2	2	2	1	1	1	-	-
J	-	-	-	4	3	3	2	2	2	2	2	1	1	1	-
K	-	-	-	-	4	3	3	3	2	2	2	2	1	1	1
L	-	-	-	-	4	3	3	3	3	3	2	2	2	1	1
M	-	-	-	-	-	4	3	3	3	3	3	2	2	2	1
N	-	-	-	-	-	4	4	4	3	3	3	3	2	2	2
P	-	-	-	-	-	-	4	4	4	4	3	3	3	2	2
Q	-	-	-	-	-	-	-	4	4	4	4	3	3	3	2
R	-	-	-	-	-	-	-	-	4	4	4	4	3	3	3
S	-	-	-	-	-	-	-	-	-	4	4	4	4	3	3
T	-	-	-	-	-	-	-	-	-	-	4	4	4	4	4
U	-	-	-	-	-	-	-	-	-	-	-	4	4	4	4
V	-	-	-	-	-	-	-	-	-	-	-	-	4	4	4
W	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4
X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
Y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Z	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Capital ships and larger civilian ships over 2000 tonnes use the Capital Ship Stardrive Potential Table to calculate the space requirements for a stardrive. Capital ship Stardrives cost 2MCr per dT.

Jump Rating	1	2	3	4
% of displacement	2	3	4	5

The Slipdrive

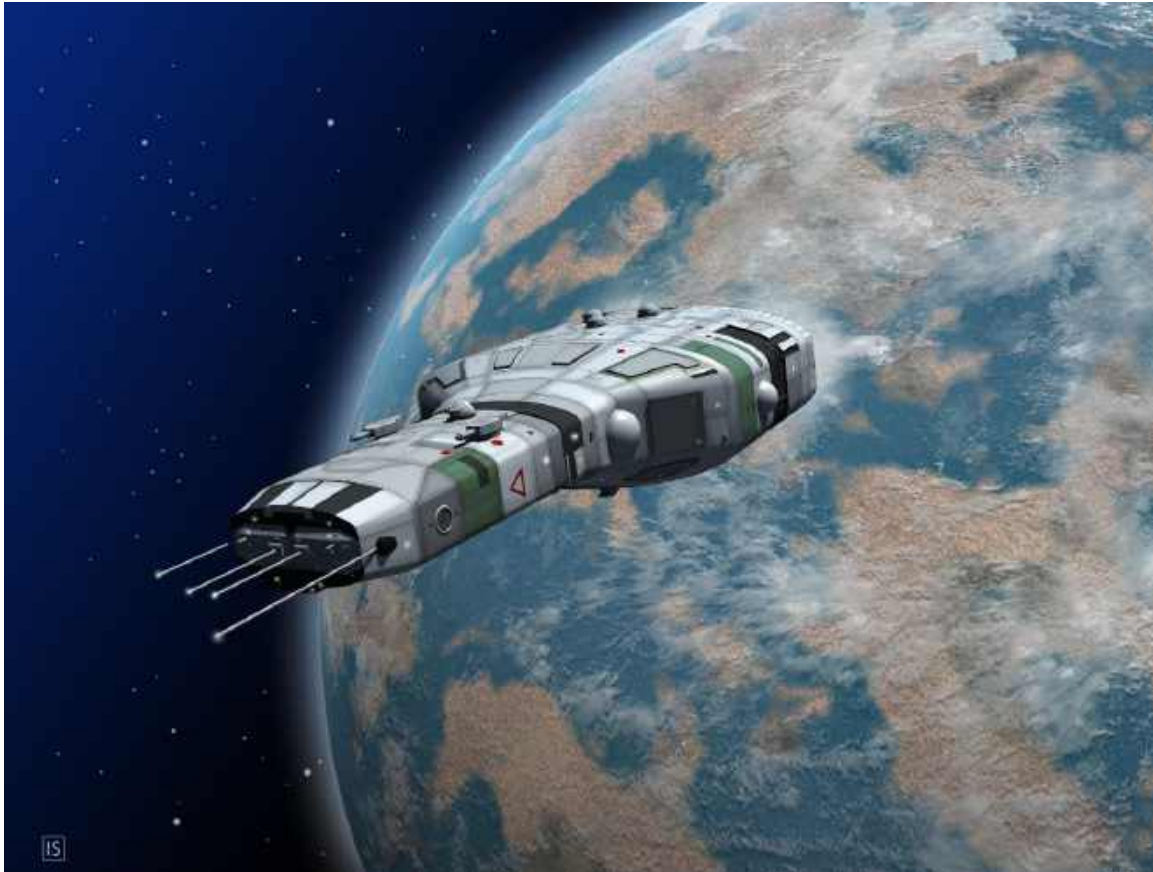
Capable of allowing starships to cross up to four parsecs in a single transit instantly, Slipdrives can be fitted into vessels one hundred tonnes or larger. A Slipdrive cannot operate within a two hundred diameter radius of any planetary body.

Slipdrives use the same selection tables and have the same software requirements as a Stardrive. They consume half the fuel per transition, are three times the cost and are two times the tonnage of an equivalent rated Stardrive.

Stardrive Software

For a Stardrive to function, software is required to operate it. Appropriate Stardrive software must be installed for the Stardrive's rating.

Program	TL	Rating	Cost (MCr)	Effect
Stardrive Control/1	9	5	0.1	Allows FTL transitions up to the specified number. Incorporates astrogation software and Stardrive management.
Stardrive Control/2	11	10	0.2	
Stardrive Control/3	12	15	0.3	
Stardrive Control/4	13	20	0.4	



Alcubierre Drive

First proposed in the twentieth century by the theoretical physicist Miguel Alcubierre as a means of interstellar travel by not violating Einstein's laws of relativity, the Alcubierre Drive creates faster than light movement by warping space in such a way that space contracts ahead of a starship and expands behind it. The ship remains stationary nestled inside a region of flat space called a warp bubble and be carried along as the region itself moves due to the actions of the drive.

The theory becoming practical reality at TL9, an early Alcubierre Drive equipped starship will have two distinctive rings around the main hull. These two rings, known as negative field rings, contain and control the warp field once generated. More advanced Alcubierre drives replace the physical rings with negative field ring emitter arrays which provide more efficient warp fields.

Unlike other forms of FTL drive, an Alcubierre Drive must create a warp field in a region of normal space free of gravitational influences called a "flat metric". Within a star system, flat metric

regions are usually well beyond any planetary masses, requiring the starship to travel weeks or months at constant acceleration to reach.

A starship with an Alcubierre Drive can travel approximately a light year per day, or about two parsecs in a week.

An Alcubierre Drive is considerably larger than a Zimm Drive due to the paired negative field rings required to generate the warp field required to propel a ship at faster than light velocities and the particle energy accumulators that are used to power the drive. At TL12 advances in drive technology allow for the physical field rings to be replaced by a ring of negative field emitter arrays.

Additional substantive radiation hull shielding will be required to protect the interior of the vessel. Without this additional shielding Hawking radiation will kill the crew within seconds of the drive field being generated.

Because stored fuel is only needed by the drive to provide power to initiate the warp field, the fuel requirement for an Alcubierre Drive is much lower than a Zimm Drive. To maintain the warp field stored energy from particles that the warp field accumulates is used as a power source. On drive deactivation at the destination, the accumulators dissipate the remaining energy stored in a controlled manner. Alcubierre Drive starships announce their arrival in a burst of hard radiation and light far greater than a Zimm Drive.

To add an Alcubierre Drive to a starship design, the following design steps must be undertaken.

1. Calculate drive letter based on design hull tonnage.
2. Determine drive size and cost.
3. Determine Particle Energy Accumulator requirement.
4. Determine Negative Field Ring or Emitter Array requirement.
5. Determine Warp Field Radiation Shield requirement.
6. Determine initialization fuel tankage.

An Alcubierre Drive cannot be installed on vessels smaller than 100 tonnes.

To determine which drive letter to use for an Alcubierre Drive consult the table below.

Alcubierre Drive Letter Table

Hull	100	200	300	400	500	600	700	800	900	1000	1200	1400	1600	1800	2000
Drive	A	B	C	D	G	H	J	J	K	K	L	M	N	P	Q

Alcubierre Drive Cost Table

Code	Tonnes	MCr.
A	20	20
B	30	35
C	40	45
D	50	55
E	60	65
F	75	70
G	80	80
H	90	90
J	100	105
K	110	120
L	120	130
M	130	140
N	140	150
P	150	160
Q	160	180

Capital Ship Alcubierre Drives

For vessels between 2001 and 5000 tonnes, an Alcubierre Drive will require 8% of the ship's tonnage and cost 3MCr per dT.

Particle Energy Accumulators

The space requirement for a Particle Energy Accumulator is 10% of the selected hull tonnage.

Negative Field Rings and Emitter Arrays

The paired negative field rings required to generate a warp field require a space of 10% of the ship's tonnage. Cost is 1.5MCr per dT. Negative Field Emitter Arrays replace the rings at TL12 requiring 5% of the ship's tonnage. Cost is 2MCr per dT.

Warp Field Radiation Shielding

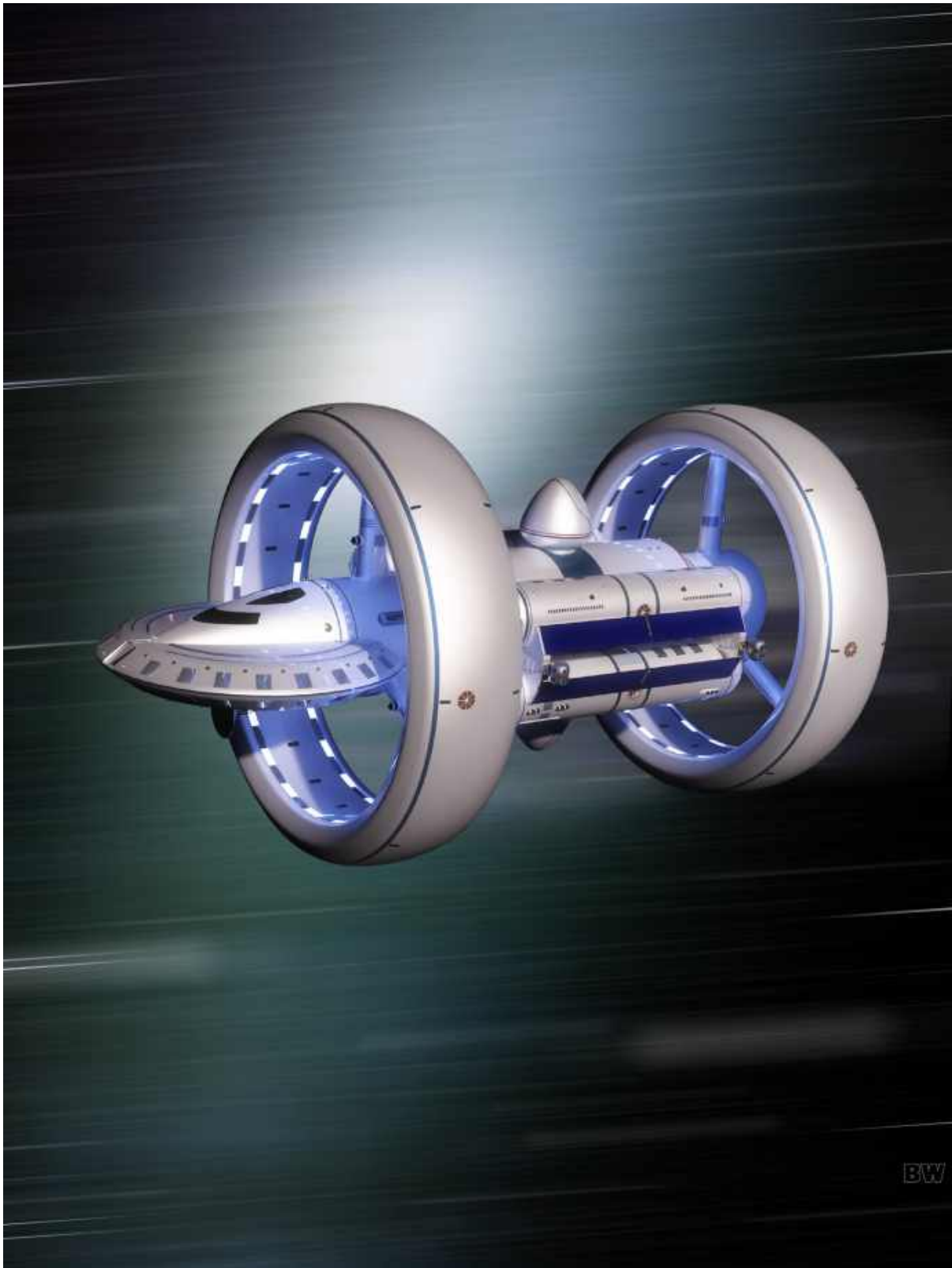
Normally a ship's hull equipped with radiation shielding (see page 31) will provide very good protection from the hazards of normal space travel, but travel using an Alcubierre Drive requires more shielding to prevent Hawking radiation and other radiation types from sterilizing the interior of the ship within seconds of the warp field being generated.

A radiation shield generator requires 1% of the selected hull tonnage and costs 0.5MCr per dT.

Fuel

The fuel used by an Alcubierre Drive for warp bubble initialization is 5% of the hull tonnage.

For example, a 200-tonne ship would require $200 \times 0.05 = 10\text{dT}$ Fuel to initialize a warp bubble.



Module 5 - Advanced Space Combat

While the standard space combat rules in *Clement Sector* pages 410 – 432 can be used for space combat, the advanced combat rules can be optionally used to reflect the greater firepower, heavier weapons, highly trained crews, and the bigger sizes of the vessels involved.

Capital Ship Section Allocation

Capital Ships hulls are subdivided into two or more sections with hull and structure points spread evenly across each section. The number of hull sections is determined by the size of the ship.

A capital ship design will have a Section Hit Table created which distributes all major internal external components, weapons, drives, hull points and fuel. This customized table is the Hit Location table for that particular capital ship. For further details on how to create the Section Hit Locate tables for capital ship designs refer to page 110.

Example Section Hit Table for Moltke-class Cruiser

	Engineering		Forward	
Hull	25		25	
Structure	25		25	
Roll	External	Internal	External	Internal
2	Hull	Crew	Hull	Crew
3	Engineering	Z-Drive	Bay	Bridge
4	M-Drive	P-Plant	Small Craft	Computer
5	Turret	Fuel	Turret	Fuel
6	Hull	Structure	Hull	Structure
7	Armor	Hold	Armor	Hold
8	Hull	Structure	Hull	Structure
9	Bay	Fuel	Bay	Fuel
10	M-Drive	Z-Drive	Turret	Command Bridge
11	Bay	P-Plant	Sensor array	Magazine
12	Hull	Critical	Hull	Critical

Capital Ship Space Combat Initiative

Advanced space combat uses the same initiative roll of 2d6 as per standard space combat eschewing the additional DMs of faster acceleration and ship's pilot skill.

Capital ships add their Crew Skill (see page 111) and the captain's Tactics (Naval) skill level as DMs to their total Initiative. If it is to be a fleet engagement (more than one ship) then the senior officer, squadron or fleet commander can use their Tactics (Naval) skill level as a DM to the initiative roll rather than individual ship captain's skill level.

Attack Resolution

Instead of resolving all the attacks from any one ship at once, capital ships will exchange barrage fire (see below) or engage in other actions such as maneuvering or initiating boarding. Each ship engaged in combat makes one attack in descending order of initiative, then repeating from

highest initiative once all ships have completed their action. This process continues until the combat is resolved or all combat actions have ceased.

Range

The range of a weapon plays a critical part in that weapons accuracy and in the vast reaches of space such massive distances will affect targeting accuracy, cause damage attenuation of energy weapons and require highly accurate firing solutions for projectile weapons, missiles, and torpedoes.

For a missile to hit a target, roll for accuracy applying Gunner (Turret) or Gunner (Capital Weapons) where appropriate. Further modification to the result is determined by the Weapon Range table below.

Weapon or Optimum Range	Weapon Ranges								
	Adjacent	Adjacent	Close	Short	Medium	Long	Very Long	Distant	Very Distant
	(small craft shooting)								
Missile*	-2	N/A	N/A	-1	+0	+0	+0	-2	-
Torpedo	-2	-3	-2	-1	+0	+0	+0	-2	-
Short	0	-1	+0	+0	-4	-	-	-	-
Medium	-1	-2	-1	+0	+0	-2	-	-	-
Long	-1	-3	-1	+0	+0	+0	-2	-4	-
Very Long	-1	-3	-1	+0	+0	+0	+0	-2	-

*Missile accuracy is not dependent on range except at very high distances. Missiles cannot be used at Adjacent and Close ranges simply because the missile's drive (either gravitic or reaction drive) cannot obtain high enough thrust values to be effective.

Next, check the Missile Hit table below to determine the roll the gunner must achieve using 2D6. Apply Gunner (Turret) or Gunner (Capital Weapons) as well to determine if the missile finds its target.

Gunnery Accuracy Check	Missile to Hit Roll	Gunnery Accuracy Check	Missile to Hit Roll
Failed with Effect -6 or less	11+	Succeeded with Effect 0	8+
Failed with Effect -2 to -5	10+	Succeeded with Effect 1 - 5	7+
Failed with Effect -1	9+	Succeeded with Effect 6+	6+

Refer to the *armament chapter* for the ranges of all available weapons. Spinal mounts will have an additional -1 DM penalty engaging a target at adjacent or close range

Data Interlink Net

When there are two or more ships in a squadron a data interlink net can be established to provide a greater defense umbrella. Destroyers and other escort vessels are generally used in this role to protect larger capital ships (such as cruisers and carriers) and support vessels. Additional ships will further improve the barrage defense DM and any ship losses will reduce the DM.

Ship numbers in Net	Modifier
2-3	+1
4-5	+2
5+	+3

Enemy vessels can attempt to disrupt a data interlink net making it less effective. This is a required formidable task (-6DM) with the only modifier being an electronic warfare software suite. If EW software is used for that purpose, then it cannot be used to defend against missile or torpedo attacks for that turn. If the task roll is successful, then the data interlink net is disrupted and the data interlink net DM is reduced by one step for that turn. Note that the DM cannot fall below +0.

Barrages

While basic combat between adventure class ships allows for easy tracking of each individual energy weapon, sandcaster canister or missile and thus allows for attack rolls to be tracked singly, capital ships are another matter.

A capital ship has a far higher number of turrets, barbettes and bays and while it is possible to access broadsides individually, it can be a long and time-consuming process.

To assist in tracking large numbers of weapons firing simultaneously, weapons of similar type are grouped into barrages. This barrage attack is a considered a single attack on the same target. The strength of the barrage is measured by the number of dice involved, so the greater the group weapon number, the more devastating the barrage.

For example, a single standard military missile deals 3D6 damage so a barrage of fifteen missiles would be a forty-five dice barrage.

The following notation for a barrage is as follows:

(Number of Dice) – (Weapon Type) – Range – (Individual Weapon Damage in dice)

*For example, the barrage of standard military missiles described above would be described as **45 – missile (mil standard) – long – 3**.*

No fewer than ten weapons of the same type can be included in a barrage, or all the weapons of that type mounted on the ship if the number is less than ten.

For example, a Moltke-class Cruiser of the Hub Federation Navy mounts four fifty-tonne meson gun bays. As that number is less than ten, all four must be fired in one barrage. So, the barrage is noted as 20 – meson – long – 5.

*Further examples. A capital ship is armed with six fifty-tonne missile bays, so these must be fired in one barrage. So, a standard missile barrage at long range is noted as 72 – missile (mil standard) – long – 3. (Fifty-tonne bays fire 12 missiles each) If that ship fired multiple warhead missiles, then the barrage would read 72*1D6 missile (multi) – long – 2.*

Configuration

The hull configuration of a capital ship will determine what percentage of its weapons can bear on a target. See page 28 for the Capital Ship Hull Configuration Table for the appropriate percentage. Any barrage aimed at a target is capped by that percentage bearing value.

The HFS Moltke has a streamlined hull configuration so she can only fire eighty percent of any barrage. If she fired a military standard missile barrage at long range towards an enemy ship, then the barrage notation would change from 45 – missile (mil standard) – long – 3 to 36 – missile (mil standard) – long – 3.

Instead of 15 missiles only 12 missiles can be fired at the target.

Barrage Attacks

Overall, a barrage will not really hit nor miss as even an inaccurate barrage will usually score one or two hits. The more accurate a barrage is, the more damage it will cause.

Attacking with a barrage roll is made by rolling 2D6 with dice modifiers applied for target range, fire control software, evasive maneuvering (dodging), gunner skill and the target's defenses. All but the target defenses are as per basic ship combat, with the modifiers for ship defenses worked out below. The dice modifiers for Line Up the Shot (*Clement Sector*, page 418) and missile launch accuracy check (*Clement Sector*, page 423) are not used in capital ship combat.

Barrage Net Score = Barrage Attack – Barrage Defense

For example, HFS Moltke launches a flight of fifteen standard missiles at an incoming enemy target at long range. Each missile is capable of dealing 3D6 damage if it hits its intended target, so the barrage is defined as 45 – missile (mil standard) – long – 3. The gunnery crew of the Moltke has a skill rating of 3, operating fire control/4 and Launch Solution/3 software. Detecting the incoming missile barrage the crew of the enemy ship successfully dodges the incoming fire.

The barrage attack score is calculated as follows:

Range = Long = +0

Crew skill level = +3

Fire Control/4 = +4

Launch Solution/3 = +3

Attack score is (+0) + (+3) + (+4) + (+3) = 10

Target successfully dodges incoming fire = -2

Moltke rolls a barrage attack of 8 on two dice = +8

Barrage attack score is = 10 - (-2) + (+8) = 16 and is further modified by the base armor DM below

Armor

Armor forms the main passive defense of almost all capital ships in Clement Sector, preventing or reducing damage to internal ship's systems and crew (the exception being meson attacks). (It is important to note that armor is therefore more effective against barrage attacks than individual weapon attacks).

The base armor DM is calculated as the Individual Weapon Damage (IWD) minus the armor value of the targeted ship and is applied to the barrage attack score. More powerful weapons will smash through more lightly armored ships causing major internal damage and crew casualties.

For example, the target fired upon by the Moltke's missile barrage has an armor rating of 8 and the IWD is 3 so base armor DM = 3 – 8 = -5.

Barrage attack score – target's base armor DM = 16 + (-5) = 11

Barrage Defenses

Unlike basic ship combat, barrage attacks are affected by ship defenses differently (the exception being MaGG defensive screens which will reduce damage directly as well as providing a defense DM). Instead of reducing damage directly, electronic defenses, armor and sand provide a DM to the attack roll which can be determined by summing up the protection provided by the defenses.

Electronic Defenses

A targeted ship with an electronic warfare software suite can add that software's rating DM to any defense against incoming missiles or torpedoes.

Sand

Sand will protect a ship against incoming laser or missile attacks fired from medium or longer ranges. To determine the defensive effectiveness of a sand cloud roll 1D6 modified by the table below. If the resultant number is zero or less, then the sand protection modifier to a missile, torpedo or laser barrage defense is zero.

Ratio	Protection
Number of sandcasters is 110% or more than the number of lasers or missiles	+2
Number of sandcasters is within 10% of the number of lasers or missiles	+0
Number of sandcasters is 90% or less than the number of lasers or missiles	-2
Incoming attacks are high energy lasers from bomb pumped torpedoes or mines	-2
Gunner skill 3+	+1

The MaGG Screen

The Magnetogravitic screen is a recent technological development believed to have recently been fitted into the Hub Federation Navy's *Moltke*-class and New Perth Navy's *Australia*-class cruisers. See page 87 for details.

MaGG screens add to the defense of a ship against high energy particles (meson guns, particle beams, fusion guns, and nuclear weapons). With a MaGG screen active the crew of the protected ship will suffer no radiation damage. MaGG screens provide two points of protection per installed screen (+3 if the Screens to Maximum action is optionally used) and reduce damage by an initial 2D6 and a further 1D6 per additional screen layer installed.

Configuration

Some hull configurations will offer protection against meson attacks due to their compact nature reducing the possibility of meson decay occurring within the ship.

Configuration	Hull Shape	Protection
Standard		+2
Streamlined	Cone	+2
	Needle/wedge	+2
	Cylinder	+2
	Cone	+2
Distributed	Close Structure	+0
	Dispersed Structure	+4

Point Defense Weapons

Point Defense Lasers

Laser weapons assigned to point defense mode will only protect against missiles or torpedoes. To determine the defensive effectiveness of point defense lasers, roll 1D6 modified by the table below. If the resultant number is zero or less, then the laser protection modifier to a missile or torpedo barrage defense is zero.

Ratio	Protection
Number of lasers is 110% or more than the number of missiles or non-bomb pumped torpedoes	+2
Number of sandcasters is within 10% of the number of missiles or torpedoes	+0
Number of lasers is 90% or less than the number of missiles or non-bomb pumped torpedoes	-1
Barrage consists of bombed pumped torpedoes	-2
Gunner skill 3+	+1

Point Defense Missiles

Fragmentation missiles can be used in the point defense role by attempting to home in and proximity detonate sending expanding clouds of high velocity shrapnel into the path of the attacking missiles. To determine the defensive effectiveness of point defense fragmentation missiles, roll 1D6 modified by the table below. If the resultant number is zero or less, then the missile protection modifier to a missile or torpedo barrage defense is zero.

Ratio	Protection
Number of missiles is 130% or more than the number of missiles or non-bomb pumped torpedoes	+2
Number of missiles is within 10% of the number of missiles or torpedoes	+0
Number of missiles is 80% or less than the number of missiles or non-bomb pumped torpedoes	-1
Barrage consists of bombed pumped torpedoes	-3
Gunner skill 3+	+1

Point Defense Railguns

Used for point defense, the railgun canister projectile comes apart at a pre-determined distance from the firing ship sending thousands of balls at very high velocity directly into the path of incoming missiles and torpedoes.

Ratio	Protection
Number of railguns is 130% or more than the number of missiles or non-bomb pumped torpedoes	+2
Number of railguns is within 10% of the number of missiles or torpedoes	+0
Number of railguns is 80% or less than the number of missiles or non-bomb pumped torpedoes	-1
Barrage consists of bombed pumped torpedoes	-2
Gunner skill 3+	+1

Point Defense Nodes

PD node arrays provide effective defense against missiles and torpedoes up to medium range freeing up the ship's turrets to engage an enemy rather than defend against it. To determine the defensive effectiveness of point defense fragmentation missiles, roll 1D6 modified by the table below. If the resultant number is zero or less, then the PD Node protection modifier to a missile or torpedo barrage defense is zero.

Ratio	Protection
Number of PD nodes is 120% or more than the number of missiles or non-bomb pumped torpedoes	+2
Number of PD nodes is within 10% of the number of missiles or torpedoes	+0
Number of nodes is 90% or less than the number of missiles or non-bomb pumped torpedoes	-1
Barrage consists of bombed pumped torpedoes	-3
Software Point Defense/2+	+1

For example, the HFS Moltke has a barrage attack of 11 before her target's defenses come into play. The enemy vessel has no active ECM, eight points of armor and no screen. Her captain has elected to use all her fifteen lasers and twelve sandcasters for point defense. Her crew has a skill level of two.

The barrage defense score is calculated as follows:

PD Lasers Roll 1D6 = 2 (15 lasers = more than 110% of incoming missiles) +2 = +4*

*Sand Roll 1D6 = 1 (12 sandcasters = within 10% of incoming missiles**) +0 = +1*

Crew skill level = +2

Barrage defense score is (+4) + (+1) + (+2) = 7

**15 lasers/12 missiles = $1.25 \times 100\% = 125\%$*

***12 sandcasters/12 missiles = $1 \times 100\% = 100\%$*

With all the calculations for barrage attack and barrage defense completed, the barrage net score can be calculated.

Barrage Net Score = Barrage Attack – Barrage Defense = 11 – 7 = 4

Splitting Barrages

If a ship is armed with enough weapons of a particular type, then it can fire at multiple targets. For instance, if a light cruiser is armed with seven triple laser turrets providing a total of twenty-one lasers grouped into two barrages of ten and eleven respectively. Along with its main armament of four fifty-tonne meson gun bays it can elect to engage one target with ten lasers, another with the four meson guns and a third with the remaining eleven lasers. All barrages of the same type fired at the same target must be combined.

Barrage Damage

Damage from a barrage is calculated from the Barrage Damage table below using the Barrage Net Score, rounding any barrage damage down. If the target is a small craft or adventure class vessel less than five hundred tonnes, then the calculated damage is multiplied by three. When the damage is greater than the combined current hull and structure points of the target it has been destroyed.

Barrage damage on capital ships is calculated differently and is covered under the Capital Ship Damage section on page 192.

For example, the HFS Moltke has launched a flight of twelve military standard missiles at an enemy ship with a Barrage Net Score of 4. From the Barrage Damage table, this means only 25% of the barrage or 3 missiles hit the target for $36 \times 25\% = 9$ points of damage.

Barrage Damage Table	
Barrage Net Score	% Barrage Damage
2 or less	0%
3	10%
4	25%
5	50%
6	75%
7	100%
8	125%
9	150%
10	175%
11	200%
12	225%
13	250%
14	275%
15	300%
16	400%
17 or more	500%

Spinal Weapon Attacks

Massive weapons that run along the spine of very large monitor class vessels, spinal mounts can cause massive damage to any target they hit. The drawback is that the monitor must align with the target, determine range and predict trajectory before it can fire. This is a required formidable task (-6DM) with the following allowed modifiers being fire control software, gunnery crew skill, range, dodge incoming fire and target size. All spinal mounts have optimal range of Long.

Target Size Modifier	
Target Hull Tonnage	Modifier
Under 10,000	-1
Under 1000	-2
Under 100	-4

The monitor MSS Hampton Roads fires at an enemy destroyer. The DM's that will be applied to the 2D6 to hit roll are:

Task (formidable) -6, fire control/4 +4, crew skill +2, enemy vessel is dodging under fire -2, target is 1200 tons -1. So, the net DM to hit is $(-6) + (+4) + (+2) + (-2) + (-1) = -3$. To hit her target Hampton Roads requires a roll of 11+.

Even though a meson gun spinal mount might hit the target, it first must penetrate an active MaGG screen to ensure meson decay within the ship. The target's hull configuration can also prevent meson decay from occurring.

Cross check the penetration rating of the meson gun against the configuration of the targeted ship and the number of screen points being generated (2 points per installed screen or 3 points if the Screens to Maximum action is being optionally used) and then roll the number indicated on 2D6 to see if the shot penetrates the ship's defenses.



<i>Meson Gun Penetration Rating</i>					
Hull Configuration	MaGG Screen Points	I	II	III	IV
Close Structure or Sphere	0	Automatic Penetration	Automatic Penetration	Automatic Penetration	Automatic Penetration
	Up to 4	6	4	Automatic Penetration	Automatic Penetration
	6	7	5	3	Automatic Penetration
	8 -9	8	6	4	Automatic Penetration
	10	9	6	4	Automatic Penetration
	12	10	8	6	4
	15	11	9	7	5
	18	12	10	8	6
	0	4	Automatic Penetration	Automatic Penetration	Automatic Penetration
	Up to 4	6	4	Automatic Penetration	Automatic Penetration
Streamlined or Standard	6	7	5	3	Automatic Penetration
	8 -9	9	6	4	Automatic Penetration
	10	9	7	5	Automatic Penetration
	12	9	8	6	4
	15	11	9	7	5
	18	12	10	8	6
	0	8	6	5	4
	Up to 4	8	7	5	4
	6	9	7	5	4
	8 - 10	10	8	6	4
Dispersed	12	11	9	6	4
	15	11	9	7	5
	18	12	11	8	6
	18	12	11	8	6

Particle beam spinal mount damage is reduced by 30 damage points for every 1 armor point, to a minimum of 0 damage points.

Residual damage still occurs with a particle beam spinal mount hit. Divide the damage value absorbed by the target ship's armor by 10. Apply this as a standard barrage to a single section, even if the spinal mount did no damage otherwise. This hit cannot be a system hit.

Example one, a Type A particle beam spinal mount capable of inflicting 200 points of damage successfully hits a ship with 4 points of armor. So, 120 points of damage (4 x 30) is absorbed by the armor and the remaining 80 points is treated as spinal weapon damage and (4 x 30 x 10%) = 12 points is treated as a barrage hit on the section hit by the spinal mount.

Example two, the Type A particle beam spinal mount hits a ship with 8 points of amour. The armor absorption is calculated as $[200 - (8 \times 30)]$, so 0 damage is treated as spinal weapon damage. In this case the spinal mount damage is absorbed entirely by the armor so $(200 \times 10\%) = 20$ damage is thus treated as a barrage hit on the section hit by the spinal mount.

A ship equipped with an active MaGG screen will also have damage reduced depending on the number of active screen layers (see p. 185). Damage reduction is always applied to the spinal weapon damage when defending against a spinal weapon attack.

Both particle beam and meson spinal mounts will inflict radiation damage. To determine this, divide the damage inflicted on the ship by the spinal mount (including any residual damage from particle beam hits) by 6 (rounding down) to find the radiation damage inflicted. If the ship has radiation shielding divide the result further by 2. If the ship has an active MaGG field, then all radiation damage is negated.

Using example one above, the particle beam caused a total of (80 spinal damage + 12 residual damage) = 92 points of damage. The radiation hits inflicted are $(92/6) = 15$.

Railgun spinal mounts are less effective at hitting more mobile targets at longer ranges than meson or particle spinal mounts due to the sublight speed of the projectile. However, for targets that are in predictable trajectories) or non-moving ground targets such as fortifications) they are exceedingly effective.

Any mobile target over medium range suffers a -1 DM to achieve a hit and if that target is over long range that penalty increases to -2 DM. Any small target to-hit penalties also apply.

For a stationary or predictable path target (such as orbital facilities) there is a +1 DM over medium range. Predictable path targets can have their trajectories or course analyzed by the firing vessel with a high degree of accuracy and the projectile fired to intercept the target.

Railgun Spinal Mount Penetration is graded on the amount of damage they inflict in accordance with the railgun penetration table on page 86.

Railgun spinal mounts ignore armor equal to three times its penetration rating with any residual armor reducing the damage inflicted on a successful hit by twenty times per point of armor remaining.

For example, a 250-damage type II railgun spinal mount is fired at a light cruiser with 8 points of crystaliron armor within optimum range. As a type II penetration weapon, it ignores six armor points leaving 2 points. Damage to a single section of the light cruiser is calculated to be $250 - (2 \times 20) = 210$ damage.

Spinal weapon damage is then resolved as below.

Capital Ship Damage

Capital ships are large and complex, with a full maintenance crew, damage control teams and repair drones working continuously to repair or restore damaged systems. Because of their size and complexity, there are too many turrets and components to track damage individually.

The basic combat damage rules can be used when a small craft (such as a fighter) or an adventure class ship is attacking a capital ship. However, a third hit on drives, power plants, sensors or a bridge system on a capital ship is impossible.

Follow the sequence below to determine damage results caused by barrage and spinal weapon attacks.

Location

Determine the location of the attack on the target by rolling to determine which section is hit. Once that section has been determined any barrage attack will split its damage equally between the section hit and any one adjacent section chosen by the attacking ship. Spinal weapons however will inflict damage only on the section determined by the location roll.

On a CK code hull, the forward section is adjacent to the main section and the engineering is adjacent to main. In turn the main section is adjacent to both.

Apply Damage

Apply any damage from the attack from the hull points of the section hit. If hull points for that section are reduced to zero, then remaining damage is applied to the structure points of that section. If hull points are already at zero, then damage is fully applied to the structure points of that section.

Meson weapons ignore any hull points and damage the ship's structure itself.

If a section is reduced to zero structure points, then that section is destroyed, and the ship is disabled or destroyed.

Damage Location

Hull Code		
Roll	CA to CE	CF to CK
1	Engineering	Engineering
2	Engineering	Engineering
3	Engineering	Main
4	Forward	Main
5	Forward	Forward
6	Forward	Forward

System Damage

If the Barrage Attack roll was 8+ then a barrage may have inflicted some system damage. Using the ship's section hit table (see page 110), roll 1D6 to determine what system is damaged within that section.

If the damaged section has remaining hull points, then roll on that section's external column. If there are no remaining hull points, then roll on the internal column. Meson weapons will only roll on the internal column.

Spinal weapons will roll once on the section hit table per 50 points of inflicted damage. This excludes any residual particle beam weapon damage.

Turrets

First Hit

Any hit on a turret will incur a -1D6 DM to all barrages of that turret type. This DM is to be re-rolled for each barrage until the damaged turret is repaired.

Second Hit

DM is increased to -1D6+1.

Third Hit

The turret cannot continue to fire.

Barbettes

First Hit

Any hit on a barbette will incur a -1D6 DM to all barrages of that barbette type. This DM is to be re-rolled for each barrage until the damaged barbette is repaired.

Second Hit

DM is increased to -1D6+1.

Third Hit

The barbette cannot continue to fire



Bays

First Hit

Any hit on a bay will incur a -1D6 DM to all barrages of that bay type. This DM is to be re-rolled for each barrage until the damaged bay is repaired.

Second Hit

DM is increased to -1D6+1.

Third Hit

The bay cannot continue to fire.

Spinal Weapon

First Hit

If a spinal weapon is hit, then there will be a -2DM when it is

Second Hit

The spinal weapon cannot continue to fire.

Hull

The hull is further damaged by an explosion on the hull surface. This inflicts additional damage equal to half the damage inflicted by the barrage.

Armor

An armor hit will reduce the armor of that section by 1.

Structure

A hit on the structure of the ship indicates an external explosion strong enough to damage the section structure or an internal structure failure. This inflicts additional damage equal to half the damage inflicted by the barrage.

MaGG Screen

Any damage to a MaGG screen's generator or emitters reduces protection offered by the screen by 2 until repairs are completed.

Zimm Drive

First Hit

The first hit on a Zimm drive requires a - 1D6 DM to all transition attempts until the drive is repaired.

Second Hit

The Zimm drive is disabled.

Maneuver Drive

Each hit on a Maneuver drive reduces the ship's Thrust by 1 until the damage is repaired.

Power Plant

First Hit

Any damage to a power plant will reduce a capital ship's ability to use energy weapons, to maneuver or even use its Zimm drive. Reduce the power plant rating by 1.

Second Hit

Reduce the power plant rating by 2

Third Hit

The power plant is disabled, and the ship has no power unless there is an emergency backup.

Fuel

1D6 x 5% of fuel tankage is lost.

Sensors

First Hit

Damaged sensors reduce the ability for the ship to "see" around it. Apply a -1D6 DM to all Sensors checks made using the sensors in that section. This DM is rolled once, and that value used until the damaged sensors are repaired.

Second Hit

Sensors in that section are disabled.

Computer

First Hit

Any rolls made by the capital ship will have a -1DM

Second Hit

All rolls made by the capital ship will have a – 1D6 DM re-rolled for each action made.

Third Hit

The computer is disabled, and the ship cannot transit or able to fire weapons at targets beyond Close range.

Bridge

First Hit

A bridge hit will prevent the ship from maneuvering being able to transit in the next turn.

Second Hit

The bridge is destroyed, and command will automatically transfer to the CIC or secondary Bridge. The ship's Initiative is halved for two turns.

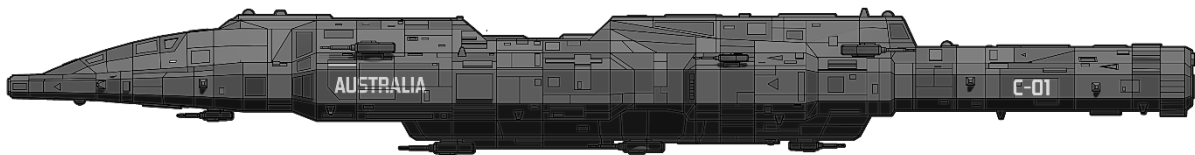
Crew

A crew hit reduces the capital ship's Crew Strength by one step.

Critical Hit

If a critical hit occurs on a section, then a major event has occurred. To determine exactly what the critical hit entails, roll 1D6 and consult the Critical Hit table.

Roll (1D6)	Critical Type	Description
1	Power Failure	The section loses power for one turn. All weapons and components within that section cannot be used until the next turn.
2	Structural Failure	An entire ship section shears away. Reduce the remaining hull by 50%. If no hull remains, then reduce the remaining structure by 50%.
3	Hull breach	As damage control crews need to repair the hull breach, no other repairs to this section can be made for one turn. If the hull is self-sealing, repair is automatic and damage control can continue other repair work.
4	Internal Explosion	An explosion will cause 6D6 damage to the structure and cause another section hit.
5	Cascade Failure	Multiple systems fail. Roll twice on the Section Hit table.
6	Internal Fire	Internal fire suppression system fails and fire rages through the section. Damage Control crews must roll Discipline 8+ to put the fire out next turn or face a +1 DM to the target roll per turn. Once the roll becomes 12+ the fire spreads to another section and starting at 8+ there.



Radiation Attacks

Weapons such as nuclear weapons, particle beams, fusion guns and meson guns will cause radiation hits and the more radiation, the more chance that the ship will suffer crew, computer, or sensor hits. Radiation shielding and ships with armor ratings above 8 will prevent radiation damage from all nuclear weapons, fusion guns, and particle beams, but not meson weapons. MaGG screens, a new and expensive technology, will negate radiation damage from all weapons.

Barrage weapons that inflict radiation damage do so based on the Barrage Net Scores percentage lookup on the Barrage Damage table. The resulting damage amount is then placed within a damage band on the Radiation Damage table. The damage band can be reduced by the armor of the ship for all weapons except for meson guns. If the band reduces to 0 then there is no radiation damage. The number within the revised damage band will be the 2D6 dice roll needed to determine if there is a hit to crew, computer or sensors.

Computer and Sensor hits are treated as per the systems damage list above.

Radiation Damage				
Radiation Damage	Damage Band	Crew Hits	Computer Hits	Sensors Hits
1-10	1	6+	0	0
11-15	2	5+	0	0
16-20	3	4+	6+	0
21-30	4	3+	5+	0
31-40	5	2+	4+	6+
41-50	6	Auto	3+	5+
51-60	7	Auto	2+	4+
61-80	8	Auto	Auto	3+
81-100	9	Auto	Auto	2+
101+	10	Auto	Auto	Auto

A barrage of 12 nuclear missiles (damage dice 36) has a Barrage Net Score of 5. Checking the Barrage Damage table, this indicated a 50% Barrage Damage result, so the radiation damage is calculated is (30 x 50%) 15. On the radiation Damage table this is damage band 4. The target has armor 2, so the revised damage band is 2.

Four fifty-tonne meson gun bays (damage dice 20) have a Barrage Net Score of 9 which is 150% on the Barrage Damage table, so the radiation damage is calculated as (20 x 150%) 30. Consultation of the Radiation Damage table places this damage within damage band 4.

Repairing Damage

During the Combat and Ship Action phase a capital ship damage control crew may repair one system per section as per the basic space combat rules. If the damaged system extends through additional sections, then one attempt per section may be made to repair it.

Crew Hits

Each time a crew hit occurs it will reduce the crew strength by one step, so from full to weakened, weakened to half etc. Reduction in crew strength reduces the ship's ability to fight and operate the ship, even with the high levels of automation that ships have.

Crew Strength	Skill DM	
Dead	N/A	Cannot act
Survivors	-4	May only fire once every five turns
Skeleton	-2	May only fire once every three turns
Half	-1	May only fire once every two turns
Weakened	+0	
Full	+0	
Battle	+0	
Overstrength	+0	

Fighter Flights

Groups of similar fighters or small craft can be organized into flights or as larger squadrons, allowing them to act as a single unit like a barrage. Flight skill level is the average skill level of the craft in the flight and the thrust of the flight is determined by the craft with the lowest thrust so ensuring the flight remains together during the combat engagement. Point defense weapons from capital ships will treat the flight as a single target for barrages.

Attacks by Flights

A flight can combine their weapons into a barrage as per the barrage rules.

Attacks on Flights

A capital ship or enemy flight can attack individual craft within a flight as normal or use barrage attacks with a -4 DM. This large DM reflects the difficulty hitting multiple small targets flying individual evasive courses.

Small craft such as fighters or attack boats will have defenses of their own including armor, so the normal barrage resolution process is followed. The damage a barrage will cause to a flight is equal to the barrage net score of that barrage.

A flight will lose a number of craft calculated by dividing the sum of the hull and structure points into the barrage damage total determined from the Barrage Damage table (page 188). The number of small craft the flight will lose is further modified by the number of mounts (for example a turret) or the number of available gunners (whatever is lower) for the weapon system firing the barrage.

A flight of 24 twenty-tonne fighters (Hull 0, Structure 1) is hit by a 30-point barrage. Rolling for the barrage attack score, the attacker rolls 9 on 2D6 with -4 DM for targeting a flight for a modified roll of 5. The twenty-tonne fighters have two points of armor, so the barrage attack score is further

modified as per the armor rule on page 184. So, $2 - 2 = +0$ thus the net barrage attack score is $5 + (+0) = 5$. This result as determined by the barrage damage table results in 50% of the flight being destroyed. However, the weapon system comprising the barrage only totals five turrets, so the number of fighters destroyed is reduced to five.



Orders

The following section provides a set of optional space combat rules where the captain of a space vessel can issue one or more orders to their crew for each turn. Each order issued will reduce the number of reactions by the amount determined by each order which in turn reduces the number of reactions the ship will be able to make.

A ship's captain can issue any number of orders if the sum of those orders does not reduce the ship's initiative below zero (0). Each order can only be issued once per turn unless otherwise noted.

Initiative	Reactions
0-4	1
5-8	2
9-12	3
13+	4

Each ship captain will secretly write down orders which are then revealed simultaneously at the start of each turn.

Orders follow the format below:

Order Name

Initiative Cost: Cost per turn for a selected order.

Type: An order is assigned a type depending on when the order is executed. Combat Orders are executed in the Combat Action phase, Ship Orders are executed in the Combat and Ship Action phase and Special Orders are executed as outlined in the order description.

Requirements: Orders may be subject to a specific requirement, such as a certain skill level. Without the nominated requirement for that order, it cannot be issued.

Emergency Orders

Orders that are followed by an exclamation mark (!) are emergency orders which can be issued as a reaction to an attack instead of during the order phase. Only one emergency order can be issued by a ship per turn.

Repeatable Orders

Orders that are followed by an asterisk (*) are repeatable orders which can be issued multiple times in one turn as long as the ship has sufficient initiative to issue it.

All Hands to Abandon Ship!

Initiative Cost: 4

Type: Special

Requirements: None

If the ship is destroyed this turn, then all the surviving crew make it to the ships small craft, lifeboats or escape pods, if any.

All Hands to Repel Boarders!

Initiative Cost: 4

Type: Special

Requirements: None

If the ship is boarded this turn, the crew and ship troops have a +1 DM to rolls on the Boarding Action table (*Clement Sector*, page 422).

Boarders Away!

Initiative Cost: 4

Type: Special

Requirements: None

Brace for Incoming Fire!

Initiative Cost: 4

Type: Special

Requirements: None

If damage is sustained during this turn and suffers one or more crew hits, then roll 1D6 for each crew hit. If the roll is 4+, then ignore the crew hit.

Close Up Defenses

Initiative Cost: 4

Type: Combat

Requirements: None

The ship places itself in a position to present the smallest possible target to enemy fire. This reduces the percentages of weapons available for a barrage by 20% but imposes a -2 DM on any attacks on the ship.

Combat Air Patrol

Initiative Cost: 4

Type: Special

Requirements: Only undertaken by small craft

As per the Layered Defense order but performed by a small craft (fighter) flight. This special order also prevents the Fast Strafing Run special order being used.

Concentrate Fire

Initiative Cost: 6

Type: Combat

Requirements: None

All the ship's guns focus on a single target. This provides a +1 DM to the attack but only on that one target for the turn.

Damn the Torpedoes!

Initiative Cost: 4

Type: Special

Requirements: Crew Skill 2+

The ship closes with the enemy and into concentrated enemy fire. All attacks on it gain a +1 DM and the ship also gains a +1 DM on all its attacks.

Evasive Action*

Initiative Cost: 4

Type: Special

Requirements: None

For this turn the ship can use an extra point of thrust to dodge enemy fire. This does not count as a reaction.

Fast Strafing Run

Initiative Cost: 4

Type: Special

Requirements: Only undertaken by small craft

If an attacking small craft flight is within close range of a target, it can maneuver and undertake an in-close strafing run under the point defense weapons on the target vessel. Point defense has a -2 DM to hit the flight and the flight receives +2 DM to attack.

Fire at Will!

Initiative Cost: 8

Type: Combat

Requirements: None

The ship can fire all its energy weapon barrages as a single action this turn.

Full Military Power

Initiative Cost: 4

Type: Combat

Requirements: None

All power is allocated to the ships maneuver drives allowing an increase in thrust by 1. However, only half the ships turrets, barbettes, and bays (round total down) can fire during that turn.

Get the Spine Lined Up!

Initiative Cost: 2

Type: Combat

Requirements: ship fitted with spinal mount

For monitors, lining up the spinal mount with a smaller evading target some tens of thousands of kilometers away is a formidable task which requires adroit ship handling.

The spinal mount cannot be fired without this special order.

Hit the Launch Bays!

Initiative Cost: 2

Type: Combat

Requirements: Crew Skill 1+

Weapons fire is concentrated on a selected ship's enemy launch bays, launch decks and hangars. Any small craft launched from that vessel during this turn may not dodge an attack.

Just Give Me One More Shot*

Initiative Cost: 2

Type: Special

Requirements: Crew Skill 3+

One damaged weapon system is restored to full functionality for one turn after which it ceases to function.

Layered Defense

Initiative Cost: 4

Type: Combat

Requirements: None

A friendly ship within close range can be selected and attacks on that ship can be defended against using the ship's sandcasters and other defensive weapons.

Make Like a Hole in Space

Initiative Cost: 4

Type: Special

Requirements: None

Shutting down all non-essential systems and minimizing electromagnetic emissions, a ship may not move or fire this turn, or use any active sensor systems. Any attempts to detect the ship using sensors will have a -2 DM.

Optimize for Maximum Firepower

Initiative Cost: 2

Type: Combat

Requirements: Crew Skill 2+

The ship is positioned to provide maximum firepower increasing the percentage of weapons made available for combining into a barrage by 10%.

Prepare for Transition!

Initiative Cost: 4

Type: Special

Requirements: None

If the ship is near a Zimm Point, then it can attempt a transition. This order provides all Engineering (Zimm Drive) or Astrogation checks with a +2 DM.

Ready the Ship for Action

Initiative Cost: 8

Type: Ship

Requirements: None

Confident in the ability of the crew, the captain prepares the ship for action. Any skill checks other than Gunner checks have a +1 DM for this turn.

Roll The Ship!

Initiative Cost: 4

Type: Combat

Requirements: Crew Skill 1+

The ship rolls, making it harder to target specific sections of its hull which gives a –2 DM to any attacks using the Target That Section order.

Screens to Maximum!

Initiative Cost: 4

Type: Special

Requirements: None

Full power is allocated to the ship's MaGG screen. The screen now provides three points of protection per screen layer instead of two.

Target That Section*

Initiative Cost: 4

Type: Special

Requirements: Crew Skill 1+

The ship can target a specific section of an enemy vessel with one of its attacks.

Wait for the Opportunity!

Initiative Cost: 6

Type: Combat

Requirements: None

The ship may wait until all other ships have completed attacks and then make all its own allowed attacks. If other ships declare to Wait for the Opportunity, the highest initiative goes first.

We need those Drives*

Initiative Cost: 6

Type: Ship

Requirements: Crew Skill 3+

Engineering repair crews can make two extra repair rolls in the engineering section this turn.

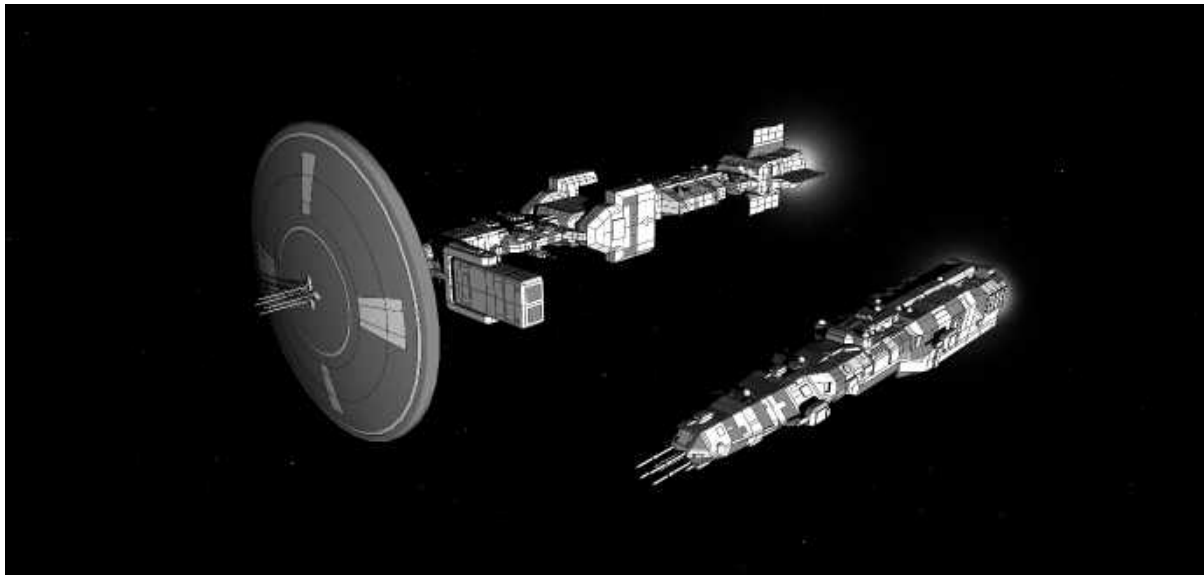
Capital Ship Barrage Attack Characteristics

Mount	Weapon Type	Range	Damage per weapon	Attack Roll DM's
Turrets	Pulse Laser	Short	2	-2
	Beam Laser	Medium	1	
	Particle Beam	Long	3 + radiation hit	
	Sandcaster	Close	1 per 4 sandcasters fired	
	Mining Laser	Adjacent	2	-4
Barbettes	Mine launcher	Special	By Mine	
	Particle Beam	Long	4	
	Plasma	Medium	4	
	Railgun	Short	By Projectile	
	Torpedo	Special	Fires one torpedo	
	X-ray Laser	Medium	3 + crew hit	
50 Tonne Bays	Missile	Special	Flight of 12 missiles	
	Particle Beam	Long	6 + crew hit	
	Torpedo	Special	Flight of six torpedoes	
	Fusion Gun	Medium	5 + crew hit	
	Meson Gun	Long	5 + crew hit	
100 Tonne Bays	Railgun	Short	By Projectile x4	
	Missile	Special	Flight of 24 missiles	
	Particle Beam	Long	9 + crew hit	
	Torpedo	Special	Flight of twelve torpedoes	
	Fusion Gun	Medium	8 + crew hit	
500 Tonne Bays	Meson Gun	Long	8 + crew hit	
	Railgun	Short	By Projectile x6	
	Particle Beam	Long	12 + crew hit	
	Fusion Gun	Medium	11	
	Meson Gun	Long	11 + crew hit	
Missiles	Railgun	Short	By Projectile x6	
	Basic	Special	1 per missile	
	Decoy	Special	Anti-missile fire -2 DM	
	Fragmentation	Special	2 per missile	
	Long Range	Special	2 per missile	
	Multi-Warhead	Special	3 per missile	
	Nuclear	Special	3 per missile	
	Ortillery	Adjacent	4 per missile	
	Shockwave	Special	Negate use of sandcasters if at least 5% damage inflicted	
	Standard Military (smart)	Special	3 per missile	
Torpedoes	Basic	Special	4 per torpedo	
	Nuclear	Special	6 per torpedo + crew hit	
	Bomb Pumped	Special	7 per torpedo	-2 for point defenses
	Ortillery	Special	8 per torpedo	-2, additional +1 for point defenses
	Multi-Warhead	Special	4 per missile	
	Multi-Warhead (Nuclear)	Special	5 per missile + crew hit	

	Multi-Warhead (Bomb Pumped)	Special	6 per missile	
Sandcasters	Chaff	Close	Disrupts comms, sensors and missile attacks	Additional +1 for point defenses
	Pebbles	Close	1 per 2 pebbles fired	
	Sand	Close	1 per 4 sandcasters fired	
	Sandcutter	Close	Halves protection of defensive sand clouds	
Railguns	Basic Kinetic Kill	Short	3 per projectile	
	Canister	Short	3 per projectile	
	Penetrator	Short	4 per projectile	
Mines	Bomb Pumped	Special	5 per mine	
	Nuclear	Adjacent	4 per mine + crew hit	
	Standard	Adjacent	3 per mine	



Module 6 - Spacecraft of Clement Sector



"The Hub Federation Navy? Those guys always politely warn you in both English and German. ONCE. The next warning is fatal." - Jermone Sorlney ex-pirate, Donar penal system participant, 2340 (standard)

The following are examples of space vessels that might be encountered within Clement Sector. All have been designed using this publication. These vessels are all covered more fully in the Independence Games' *Ships of Clement Sector* books*.

*Please note that some of the presented ship design data has been updated to reflect the latest version of this publication and might vary slightly from the *Ships of Clement Sector* series books.

Hub Federation Navy *FA-135C Reaver* Aerospace Fighter

In service with the Royal Navy Fleet Aerospace Arm for five years prior to the Collapse, the ten-tonne *Reaver* is now used as the Hub Federation Navy and Marine Corp's standard aerospace fighter. Carrying a mix of weapons, the *Reaver* is equally at home within planetary atmospheres or in space.

Kingston Defence Forces *Fire of the Holy* - Class Missile Attack Boat (MAB)

Kingston's answer to the Hub Federation Navy's potent attack boats, the MAB's primary role is to bring coordinated multi-craft mass fire missile attacks against enemy forces, overwhelming point defenses. Only time will tell if the missile boat will be successful in operations, but it does concern both Hub Federation Navy and Harrison System Defense Force strategists.

***Starlight* - Class Light Trader**

The *Starlight* Class breaks new ground by going against the long-held belief that larger merchant ships with their bigger cargo capacity are a profitable thus a more preferable design to offer prospective clients. The design team at Anderson and Felix Shipbuilders argued that for shipping companies this was certainly a truism, but buying into a *Billings* Class, *Rucker* Class or any other larger size starship was a very expensive exercise for an owner-operator. The small cargo capacity of the *Starlight* is better suited for high value cargo or fast cargo courier duties.

***Goldrush* - Class Belter Ship**

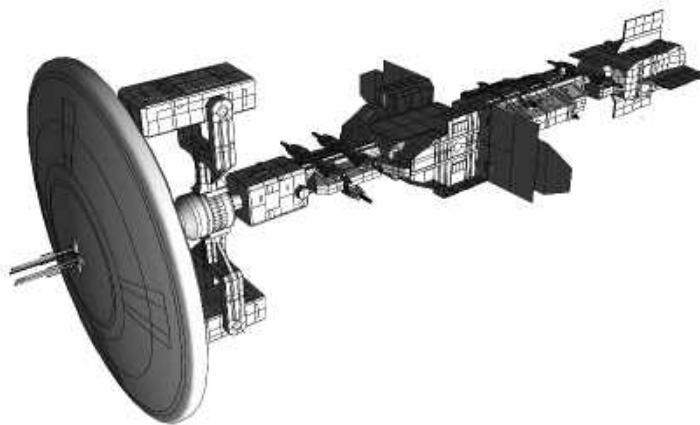
Growing more common throughout Clement Sector the *Goldrush* provides a larger more mobile base of operations for an independent group of beltors (either extended family or single owner). Designed to complement a standard fifty-tonne cutter with beltor module, the *Goldrush* has become a popular choice for beltors and small mining companies.

Hub Federation Navy *Kiviat* - Class Patrol Corvette

Designed primarily as a pirate hunter, the *Kiviat* class is a fast well-armed warship capable of fleet duties as required. The *Kiviat* class is one of the first ship classes designed specifically for the Hub Federation Navy. Captaincy of these ships is given to command rank officers who have exhibited the ability to operate independently from fleet elements and is considered a plum command for such an officer.

United States Space Navy *Trent* - Class Destroyer c2185 CE

Humanities first interstellar capable warship, the *Trent* class was a combat proven reaction drive destroyer class vessel armed with cutting edge particle beam weaponry. The majority of these vessels have long been decommissioned or turned into museums; however, two still remain in active service within Clement Sector.



Hub Federation FA-135C Reaver Aerospace Fighter

Hull and Armor

Type			Tonnes	Price (MCr)
Hull	10 Tonnes Code s1	Hull 0	10	1.1
	Streamlined	Structure 1		
Armor	Crystaliron x0.5	2 points	0.3	0.2
Hull and Armor Total			0.3	1.3

Engineering

Type			Tonnes	Price (MCr)
Maneuver Drive	Type sD	Thrust 8	2	3.5
Power Plant	Type sD	Power 8	2.1	4.5
Fuel	Powerplant	12 hours of operation	0.1	
	Fuel Scoops	Included		
	Fuel Processors	1x (2 tonnes per day)	0.5	0.1
Engineering Total			4.7	8.1

Command

Type			Tonnes	Price (MCr)
Cockpit		Single Seat (pilot)	1.5	0.05
Computer	Model 2(fib)	TL 9 Rating 10		0.24
Electronics	Basic Military	DM +0	2	1.0
Command Total			3.5	1.3

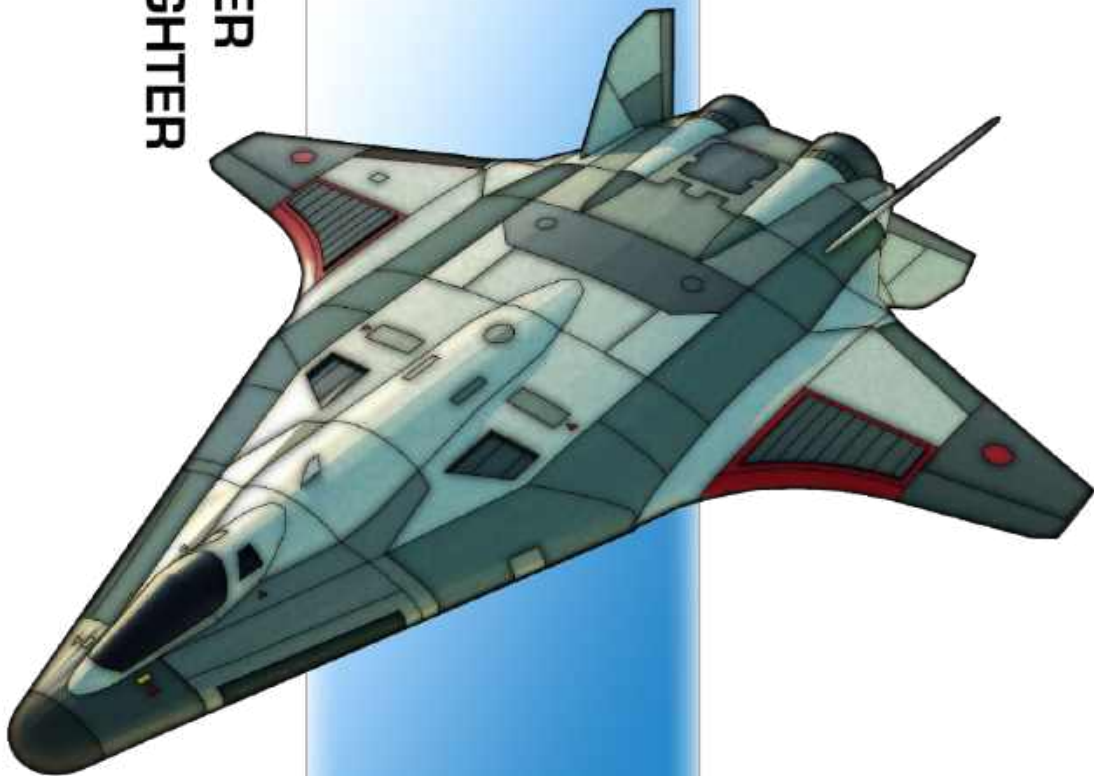
Armament and Defenses

Type			Tonnes	Price (MCr)
Weapons	Anti-Ship			
	Fixed Mount	Beam Laser	1	1.1
	Small Craft Weapon			
	Enclosed Bay	SC Missiles 12x	0.5	
	Anti-Personnel			
	Fixed Mount	Light Gauss Cannon		3.0
	Enclosed Bay	Missiles 12x		
Ammunition	Gauss Cannon	1200 rounds		
Armament and Defense Total			1.5	4.1

<i>Software</i>				
Type			Rating	Price (MCr)
Software	Evade/1		10	1
	Fire Control/1	DM+1	5	2.0
	Maneuver/Library			
Software Total				3.0

<i>Total</i>				
Type			Tonnes	Price (MCr)
Total Tonnage and Cost			10	17.8

**FA-135C REAVER
AEROSPACE FIGHTER**



Kingston Defense Forces *Fire of the Holy* - Class Missile Attack Boat (MAB)

Hull and Armor

Type			Tonnes	Price (MCr)
Hull	80 Tonnes Code S8	Hull 1	80	2.0
	Streamlined	Structure 1		0.2
Armor	Crystaliron x1	4 points	4	0.1
Hull and Armor Total			4	2.3

Engineering

Type			Tonnes	Price (MCr)
Maneuver Drive	Type sW	Thrust 5	16	32.0
Power Plant	Type sW	Rating 6	10.5	26.0
Fuel	Powerplant	2 Weeks of Operations	3.5	
	Fuel Scoops	Installed		
	Fuel Processors	1x (20 tons per day)	1	0.05
Engineering Total			31	58.0

Command

Type			Tonnes	Price (MCr)
Bridge	Control Cabin	4x workstations	12	0.4
Computer	Model 2fib	TL 9 Rating 10		0.24
Electronics	Basic Military	DM+0	2	1.0
Command Total			14	1.6

Armament and Defenses

Type			Tonnes	Price (MCr)
Weapons	Anti-Ship			
	Fixed Mount (Fwd)	Missile Launcher 2x	2	0.95
		Single Beam Laser turret (dorsal)	1	1.2
Ammunition	Missile Magazines	72x missiles per launcher	12	
Armament and Defense Total			15	2.2

Crew, Accommodation, and Internal Components

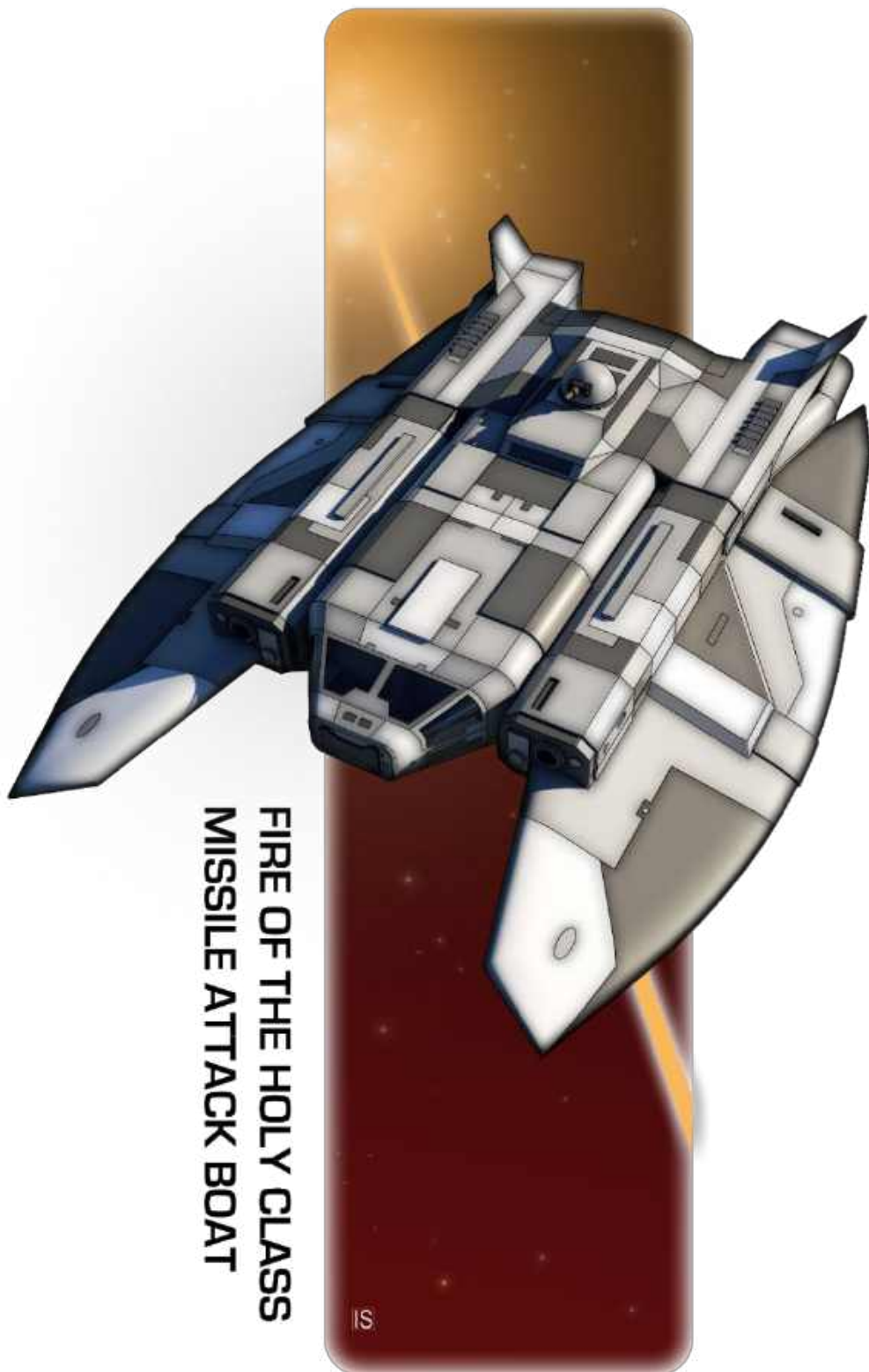
Type			Tonnes	Price (MCr)
Crew	4	commander, pilot, gunner, and engineer		
Accommodation	Crew Staterooms	3x	12	1.5
	Airlock		1	0.2
	Lifepods	3x	1.5	0.3
Cargo	1 ton		1	
Accommodation Total			15.5	2.0

Software

Type		Rating	Price (MCr)
Software	Fire Control/2	10	4.0
	Evade/1	10	1.0
	Library		
	Maneuver		
Software Total			5.0

Total

Type		Tonnes	Price (MCr)
Total Tonnage and Cost		79.5	65.9



Starlight - class Light Trader

Hull and Armor

Type			Tonnes	Price (MCr)
Hull	100 Tonnes Code 1	Hull 2	100	2.0
	Streamlined	Structure 2		0.2
Armor	Crystaliron x1	4 points	5	0.4
Hull and Armor Total			5	2.6

Engineering

Type			Tonnes	Price (MCr)
Zimm Drive	Type A	Maximum Two Parsec Transit	10	10.0
Maneuver Drive	Type B	Thrust 4	3	8.0
Power Plant	Type B	Rating 4	7	16.0
Fuel	Powerplant	Two Weeks Duration	4	
	Zimm Drive		20	
	Fuel Scoops	Installed		
	Fuel Processors	1x (20 tons per day)	1	0.05
Engineering Total			45	34.1

Command

Type			Tonnes	Price (MCr)
Bridge	Standard		10	0.5
Computer	Model 2fib	TL 9 Rating 10		0.24
Electronics	Basic Civilian	DM-2	1	0.1
Command Total			11	0.8

Armament and Defenses

Type			Tonnes	Price (MCr)
Weapons	Hardpoint 1	Not Fitted	1	
Defenses	Point Defense Nodes	None		
Ammunition	Magazines			
	Ordnance	12x Missiles or 20x Sandcaster Canisters	1	
Armament and Defense Total			2	0.0

Crew, Passengers and Accommodation

Type			Tonnes	Price (MCr)
Crew	4			
Accommodation	Crew Staterooms	4x (rated to double occupancy)	16	2.0
Accommodation Total			16	2.0

Internal Components

Type			Tonnes	Price (MCr)
Internal Components	Emergency Low Berths	1x	1	0.1
	Ship's Locker	1x		
Cargo	20 tons		20	
Internal Components Total			21	0.1

Software

Type			Rating	Price (MCr)
Software	Fire Control/1		5	2.0
	Library			
	Maneuver			
	Zimm Control		10	0.2
Software Total				2.2

Totals

Type		Tonnes	Price (MCr)
Total Tonnage and Cost		100	41.8
Maintenance Cost (Monthly)			0.003
Life Support Cost (Monthly)			0.008
Mortgage Payment (Monthly)			0.174



STARLIGHT CLASS
LIGHT MERCHANT

[S]

Goldrush - class Belter Ship

Hull and Armor

Type			Tonnes	Price (MCr)
Hull	200 Tonnes Code 2	Hull 4	200	8.0
	Standard	Structure 4		
Armor	Crystaliron x0.5	2 points	5	0.8
Hull and Armor Total			5	8.8

Engineering

Type			Tonnes	Price (MCr)
Zimm Drive	Type B	Maximum Two Parsec Transit	15	20.0
Maneuver Drive	Type B	Thrust 2	7	16.0
Power Plant	Type B	Rating 2	3	8.0
Fuel	Powerplant	Two Weeks Duration	4	
	Zimm Drive		40	
	Fuel Scoops	Installed		1.0
	Fuel Processors	1x (20 tonnes per day)	1	0.05
Engineering Total			70	45.1

Command

Type			Tonnes	Price (MCr)
Bridge	Standard		10	1.0
Computer	Model 1bis	Rating 5 (+5 Zimm Control software)		0.24
Electronics	Basic Civilian	DM-2	1	0.1
Command Total			11	1.3

Armament and Defenses

Type			Tonnes	Price (MCr)
Weapons	Hardpoint 1	Dual Turret mixed (beam laser/sandcaster)	1	1.8
	Hardpoint 2	None fitted		
Ammunition	Magazines			
	Ordnance		2	
Armament and Defenses Total			3	1.8

Crew, Passengers, and Accommodation

Type			Tonnes	Price (MCr)
Crew	4			
Accommodation	Crew Staterooms	4x (rated to double occupancy)	16	2.0
Accommodation Total			16	2.0

Internal Components

Type			Tonnes	Price (MCr)
Internal Components	Emergency Low Berths	1x	1	0.1
	Ship's Locker	1x		
	Medical Bay	One diagnostic bed	2	0.5
	Mining Drones		10	1.0
Cargo	30 tons		30	
Internal Components Total			43	1.6

Small Craft

Type			Tonnes	Price (MCr)
Small Craft	Hangar	Standard Hangar (1.1x small craft)	55	11
		1x Mining Cutter (50 tonnes) Not included in ship price		
Small Craft Total			55	11.0

Software

Type			Rating	Price (MCr)
Software	Fire Control/1		5	2.0
	Library			
	Maneuver			
	Zimm Control		10	0.2
Software Total				2.2

Totals

Type		Tonnes	Price (MCr)
Total Tonnage and Cost		200	74.2
Maintenance Cost (Monthly)			0.006
Life Support Cost (Monthly)			0.012
Mortgage Payment (Monthly)			0.309



Hub Federation Navy - Kiviat Class Patrol Corvette

Hull and Armor

Type			Tonnes	Price (MCr)
Hull	600 Tonnes Code 6	Hull 12	600	48.0
	Streamlined	Structure 12 (14)		4.8
	Self-Sealing	Included		
Armor	Crystaliron x1	4 points	30	9.6
	Reinforced Structure	2 points	30	6.0
	Radiation Shielding			60.0
Hull and Armor Total			60	128.4

Engineering

Type			Tonnes	Price (MCr)
Zimm Drive	Type H	Maximum Two Parsec Transit	45	80.0
	Military Grade			55.0
Maneuver Drive	Type S	Thrust 5	33	58.0
Power Plant	Type S	Rating 5	52	136.0
Fuel	Powerplant	Four Weeks Duration	68	
	Zimm Drive		120	
	Fuel Scoops	Installed		
	Fuel Processors	8x (160 tonnes per day)	8	0.4
	Repair Drones		6	1.2
Engineering Total			332	314.4

Command

Type			Tonnes	Price (MCr)
Bridge	Standard		20	3.0
	Holographic Controls	DM+2 (Initiative)		0.75
Computer	Model 3bis/fib x2	TL 11 Rating 15 (30)		7.5
Electronics	Advanced Sensors	DM+1	3	2.0
Command Total			23	13.3

Armament and Defenses

Type			Tonnes	Price (MCr)
Weapons	Main			
	Hardpoint 1-2	2x Particle beam barbettes	10	16.0
	Secondary			
	Hardpoint 3-4	2x Triple turret beam laser	2	8.0
	Light (turrets)			
	Hardpoint 5	Triple turret missile	1	3.25
Defenses	Hardpoint 6	Triple turret sandcaster	1	1.75
	Active			
	Point Defense Node Array	3x PD Gatling Laser		3.0
		3x PD Laser		1.5
Ammunition	Magazines			
	Missiles	72x	6	
	Sandcaster Canisters	60x	3	
Armament and Defenses Total			23	34.4

Crew and Accommodation

Type			Tonnes	Price (MCr)
Crew	34	6 officers, 24 enlisted, 6 marines		
Accommodation	Crew Staterooms	19x (rated to double occupancy)	76	9.5
Accommodation Total			76	9.5

Internal Components

Type			Tonnes	Price (MCr)
Internal Components	Armory	1x	2	0.5
	Briefing Room	1x	4	0.5
	Emergency Low Berths	2x	2	0.2
	Escape Pods	18x single	9	0.9
	Medical Bay	2x Diagnostic Beds	3	1.0
	Offices	1x	2	0.2
	Probe Drones (5)	1x	1	0.5
	Ship's Brig	4x	6	1.0
Cargo	20 tons		20	
Internal Components Total			49	4.8

Small Craft

Type			Tonnes	Price (MCr)
Small Craft	Hangar	Full Hangar (1.3x small craft)	39	7.8
		1x Armed Ship's Boat (30 tons)		
Small Craft Total			39	7.8

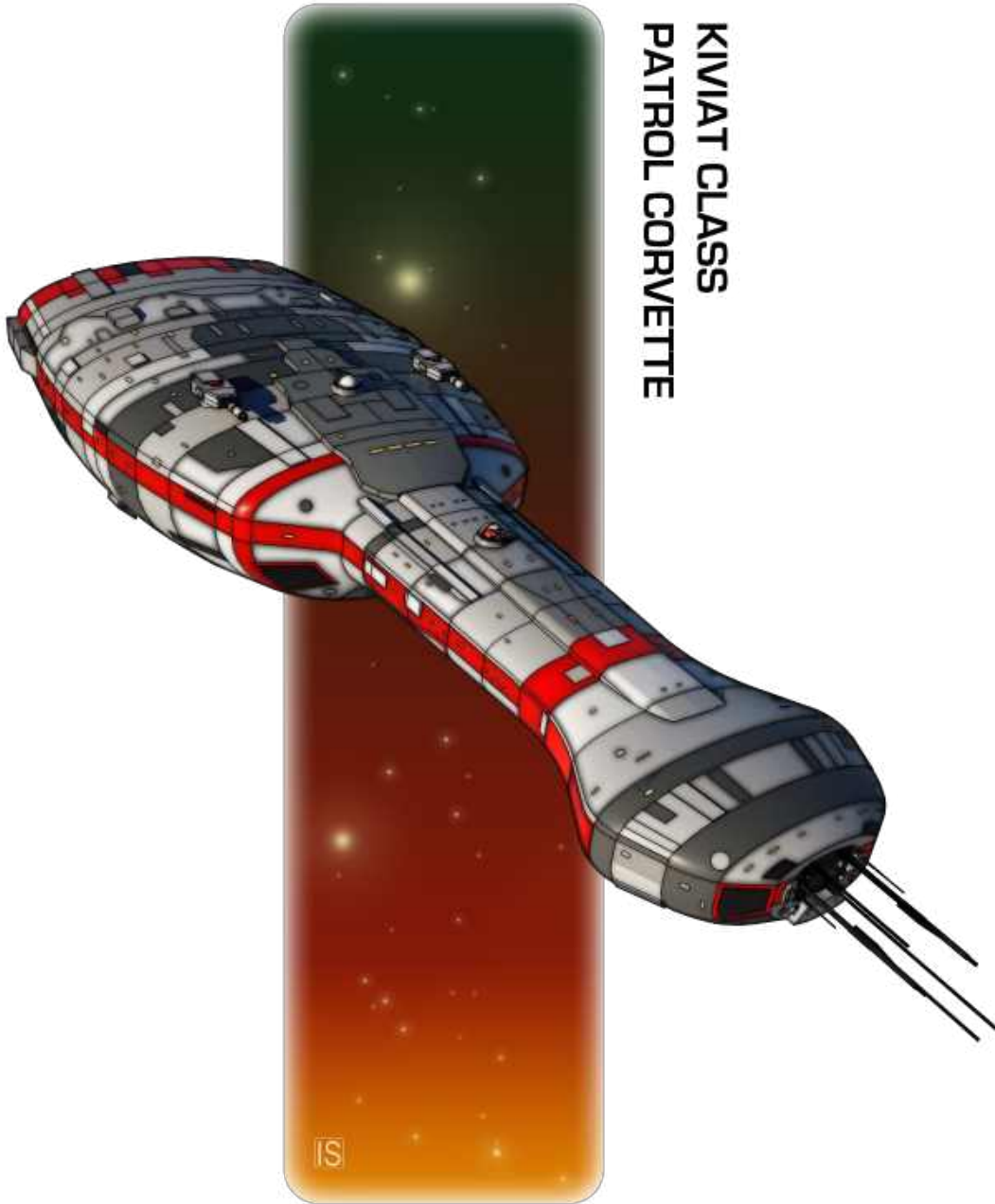
Software

Type			Rating	Price (MCr)
Software	Avatar	Type 2		0.1
	Evade/2	DM+2	15	2.0
	Fire Control/2	DM+2	10	4.0
	Intellect		10	1.0
	Internal Security/2		5	8.0
	Launch Solution/1		5	10.0
	Library			
	Maneuver			
	Point Defense/1		5	5.0
	Zimm Control		10	0.2
Software Total				30.3

Totals

Type		Tonnes	Price (MCr)
Total Tonnage and Cost		600	542.8
Maintenance Cost (Monthly)			0.045
Life Support Cost (Monthly)			0.057

**KIVIAI CLASS
PATROL CORVETTE**



United States Space Navy – Trent Class Destroyer c2185 (standard)

Hull and Armor

Type			Tonnes	Price (MCr)
Hull	1500 Tonnes Code G	Hull 30, Structure 30	1500	160.0
	Distributed Structure (close)			-16.0
	Self-Sealing	Included		
Armor	Titanium Steel x1	2 points	75	8.0
	Armored Bulkheads	Bridge	4	0.8
	Radiation Shielding			150.0
Hull and Armor Total			79	302.8

Engineering

Type			Tonnes	Price (MCr)
Zimm Drive	Type L	Maximum Two Parsec Transit	60	110.0
	Military Grade			55.0
Maneuver Drive	Type P	Fusion Plasma (Reaction) Drive Thrust 3G	33	68.0
Power Plant	Type P	Rating 3	43	112.0
	Emergency Power		4	11.2
Fuel	Powerplant	Three Weeks Duration	42	
	Reaction Mass	9 hours maximum duration at 3G	405	
	Zimm Drive	1x 2 parsec transition	300	
	Fuel Processors	10x (200 tonnes per day)	10	0.5
	Repair Drones		15	3.0
Engineering Total			912	356.7

Command

Type			Tonnes	Price (MCr)
Bridge	Standard		40	9.4
	Holographic Controls	DM+2 (Initiative)		2.3
Combat Information Centre	Included			
Computer	Model 2bis/fib x2	TL 9 Rating 10 (jump +5) ea		8.0
Electronics	Basic Military	DM+0	2	1.0
Command Total			42	20.7

Artificial Gravity and External Components

Type			Tonnes	Price (MCr)
Artificial Gravity	Extendable Spin Pods	25m radius twin pod array developing 0.7G spin gravity	105	22.0
	Improved Acceleration Protection			3.0
	Heat Dissipation Radiators		13	6.5
Command Total			118	31.5

Armament and Defenses

Type			Tonnes	Price (MCr)
Weapons	Main			
	Hardpoint 1-6	6x Particle beam barbettes	30	48.0
	Secondary			
	Hardpoint 7-8	2x Railgun Barbettes	10	8.0
	Light (turrets)			
	Hardpoint 9-11	3x Triple turret beam laser	3	12.0
	Hardpoint 12-13	2x Triple turret missile	2	6.5
	Hardpoint 14-15	2x Triple turret sandcaster	2	3.5
Ammunition	Magazines			
		Improved		2.2
	Railgun Projectiles	80x	4	
	Missiles	144x	12	
	Sandcaster Canisters	120x	6	
Armament and Defenses Total			69	80.2

Crew and Accommodation

Type			Tonnes	Price (MCr)
Crew	70	14 officers, 56 enlisted		
Accommodation	Officer's Staterooms	1x Captain's Stateroom	4	0.5
		10x Staterooms (2 tons)	20	5.0
	Officer's Heads	4x	6	0.4
	Enlisted Berths	7x	42	3.5
	Enlisted Heads	9x	11	0.9
	Galley	2x	12	3.0
	Recreation Space		14	2.8
	Bridge Crew Fresher		2	0.1
	Bridge Crew Mini Fresher		1	0.02
Accommodation Total			112	16.2

Internal Components

Type			Tonnes	Price (MCr)
Internal Components	Armory	1x	2	0.5
	Briefing Room	2x	8	1.0
	Emergency Low Berths	2x	2	0.2
	Escape Pods	30x double	30	3.0
	Gymnasium	2x	4	2.0
	Medical Bay	4x Diagnostic Beds	5	2.5
	Offices	2x	4	0.4
	Workshop	1x	4	1.0
Cargo	20 tons		20	
Internal Components Total			79	10.6

Small Craft

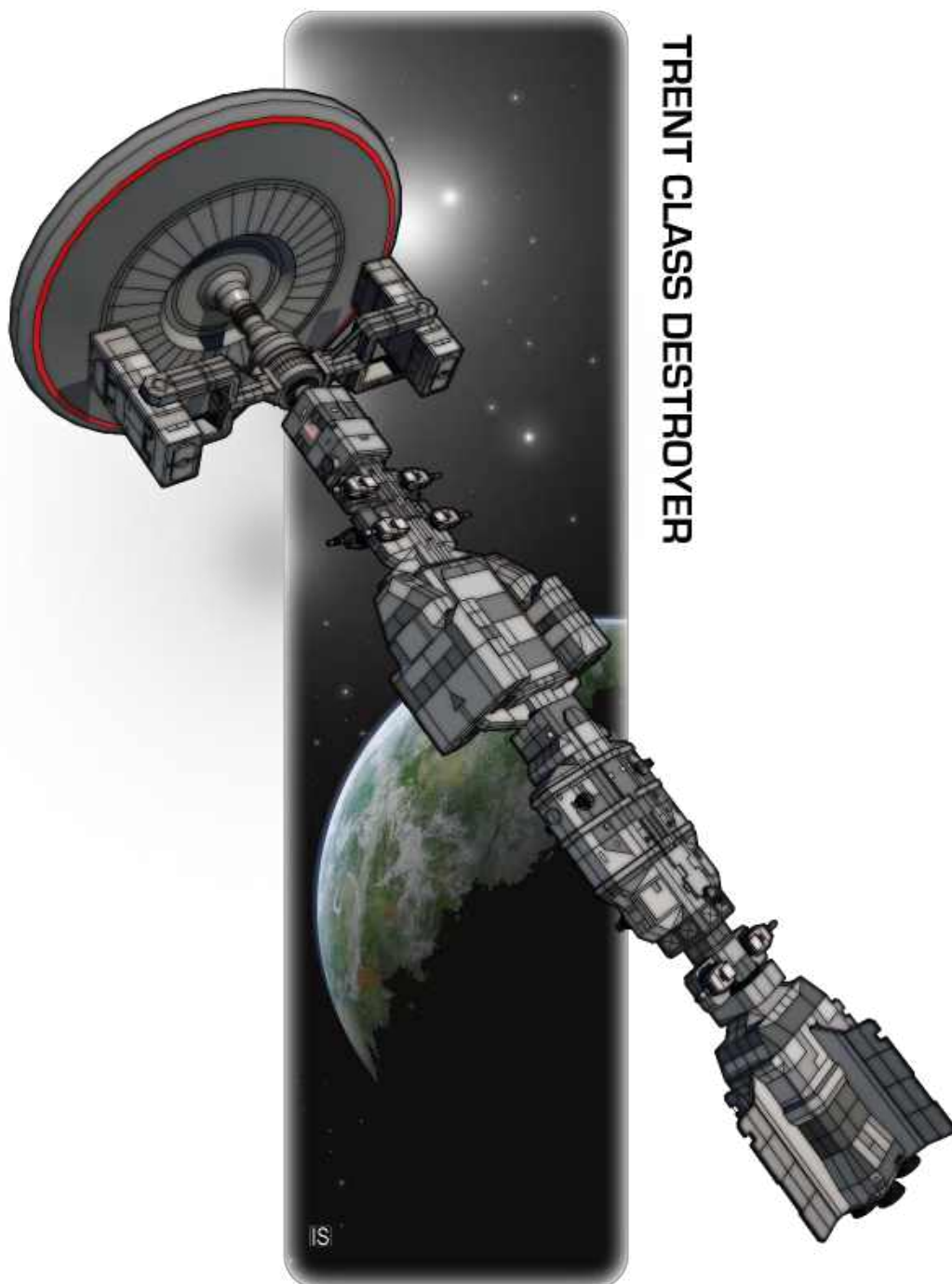
Type			Tonnes	Price (MCr)
Small Craft	Hangar	Full Hangar (1.3x small craft)	91	18.2
		2x streamlined Ship's Boat (30 tonnes)		
		1x space only Work Pod (10 tonnes)		
Small Craft Total			91	18.2

Software

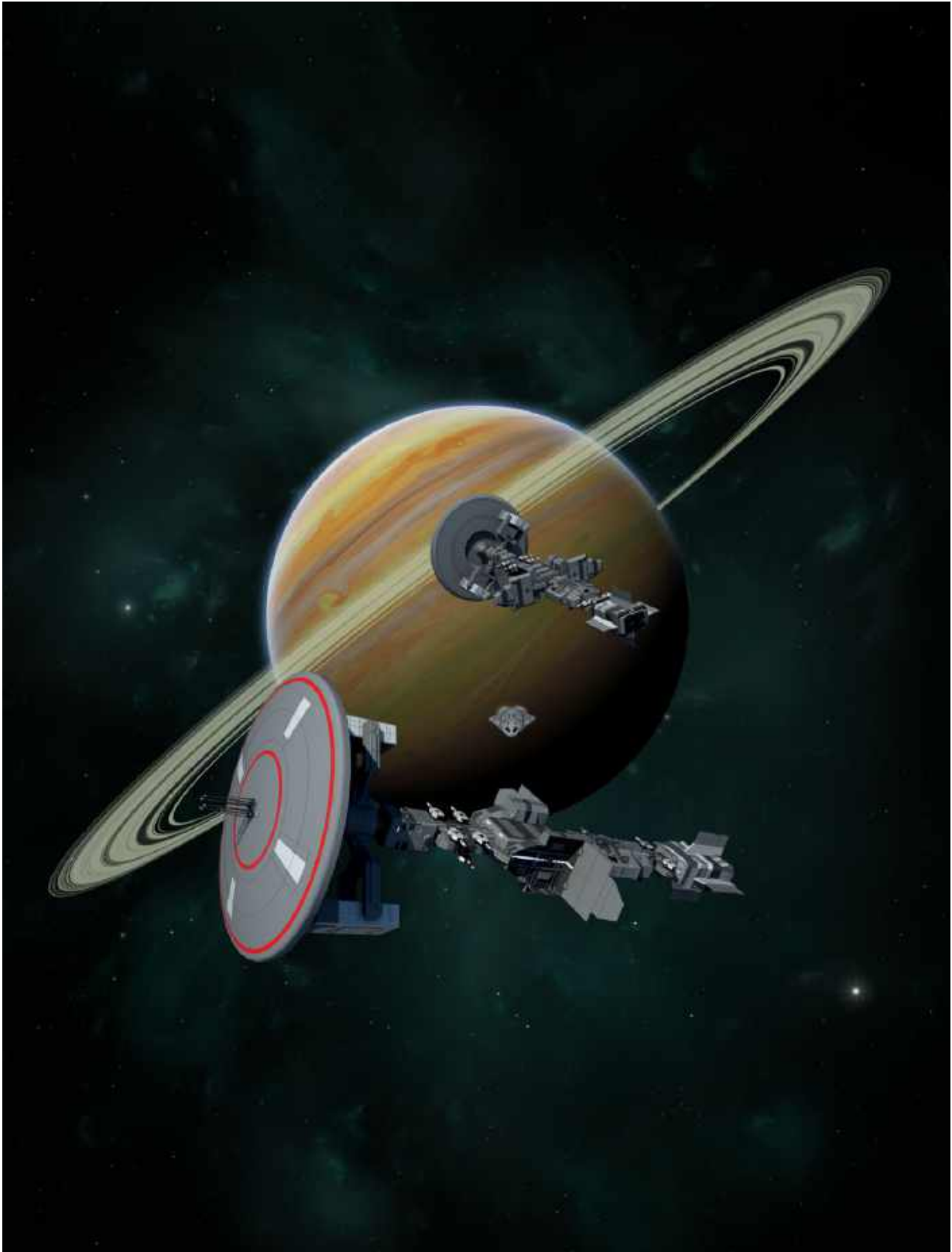
Type			Rating	Price (MCr)
Software	Electronic Warfare/1		10	15.0
	Evade/1	DM+1	10	1.0
	Fire Control/2	DM+2	10	4.0
	Internal Security/2		5	8.0
	Library			
	Maneuver			
	Zimm Control		10	0.2
Software Total				28.0

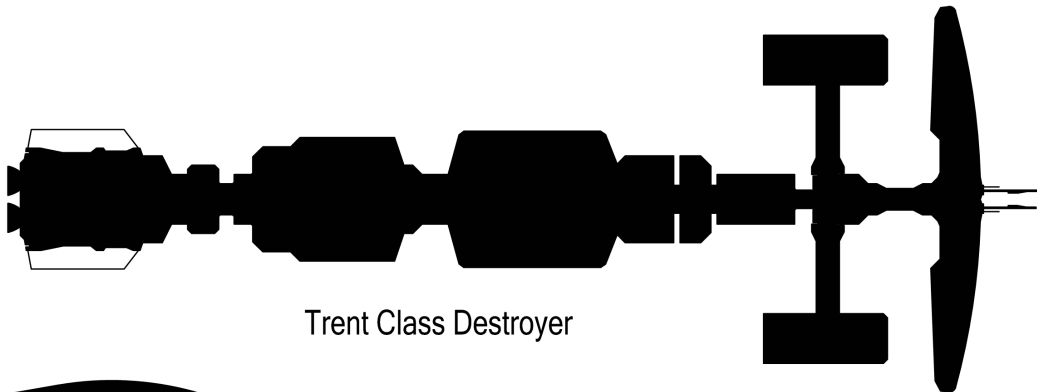
Totals

Type		Tonnes	Price (MCr)
Total Tonnage and Cost		1500	864.9
Maintenance Cost (Monthly)			0.072
Life Support Cost (Monthly)			0.043



TRENT CLASS DESTROYER

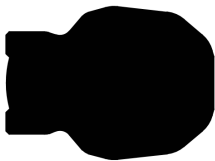




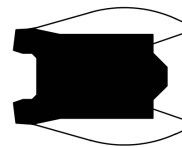
Trent Class Destroyer



Kiviat Class Patrol Corvette



Goldrush Class Belter Ship



Missile Attack Boat (MAB)



Billings Class Free Trader



SB/B-22-11 Ship's Boat



Starlight Class Light Trader



FA-135C Reaver Aerospace Fighter



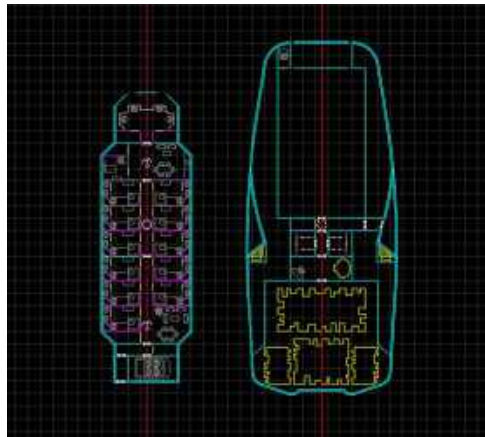
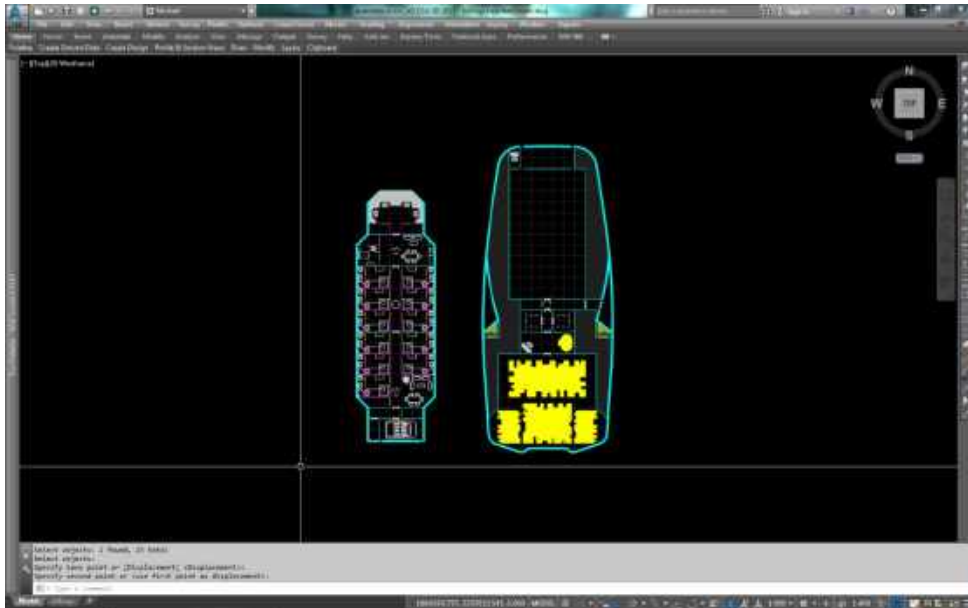
Module 7 – A Primer on Creating Deck Plans

The following is a primer to assist those who are interested in creating deck plans for the space craft they have designed. It is not a complete tutorial however but will provide a springboard into providing a more complete spacecraft design for use in a campaign, Clement Sector or otherwise.

A deck plan can be sketched using a pencil, ruler, eraser, and suitably sized graph paper readily available at stationary stores or freely printed from the website below. A graph paper with a grid of 5mm is preferred. This allows for a plan of suitable scale to be drawn.

<http://print-graph-paper.com/details/5mm>

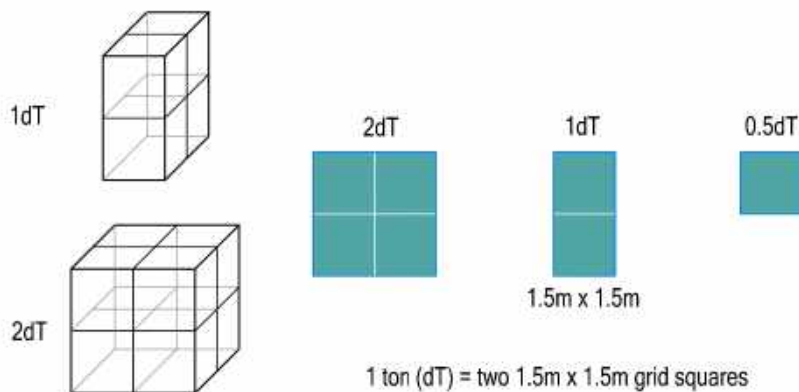
Alternatively, CAD (Computer Aided Design) software can be used. There are several very good CAD software options available that range from free up to very expensive flagship programs like AutoCAD from Autodesk. Standard architectural symbols (blocks) can also be freely sourced online that can be used to add detail to any deck plan being created.



Whether a CAD or paper option is selected, each grid square is 1.5m x 1.5m of which two grid squares on plan represents 1 tonne (dT). The diagram on the following page illustrates how grid squares work in terms of displacement tonnes.

A typical deck of a space craft is 3m in height with a 1m circulation and services access space between the underside of the deck and the overhead, making the deck height (deck to overhead) 2m. When drafting deck plans deck height assumption is already made but it is important to remember when considering internal spaces such as hangars or double height cargo holds.

Areas that are designated as fuel tanks can be half deck height or even quarter deck height if the overall hull shape and style chosen by the designer requires it.



Each displacement tonne is approximately 14 cubic meters of liquid hydrogen

To convert a plan area of grid-squares into a displacement tonne then the following calculation process is to be used.

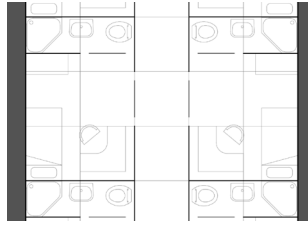
Determine the plan area of the space required to be checked then divide by the area of a single 1.5m x 1.5m grid square (2.25m^2), rounding up the resultant to determine the number of grid squares that make up the plan area. Then divide that result by two (2) to determine the displacement tonnes of that area.

For example, the plan below shows a standard 4-tonne stateroom with the obligatory one tonne amount given over to provide access corridors and common areas, leaving 3 tonnes for the stateroom proper.

*Plan Area = (3 grid squares x 1.5m) x (2 grid squares x 1.5m)
So $4.5\text{m} \times 3\text{m} = 13.5\text{m}^2$*

*Divide this area by 2.25m^2 to determine the number of grid squares.
So $13.5\text{m}^2 / 2.25\text{m}^2 = 6$ grid squares*

*Divide the number of grid squares by 2 (2 grid squares per tonne) to determine tonnes.
So $6 / 2 = 3$ tonnes*



Obviously, this is a very simple example of small rectangular area where the number of grid squares and the tonnage can be ready determined. For irregular areas such as fuel tanks or engineering spaces determining the number of grid squares can be more difficult visually and this calculation can be used to quickly determine the number of squares and then the tonnage displaced.

The table below provides a quick reference between displacement tonnes, plan area and number of grid squares.

Grid Squares	Plan Area (m ²)	Tonnes (dT)
1	2.25	0.5
2	4.5	1
4	9	2
6	13.5	3
8	18	4
10	22.5	5
12	27	6
14	31.5	7
16	36	8

Up to twenty percent (20%) allowance over the hull tonnage is allowed. This provides for armor, additional internal accesses, and storage etc.



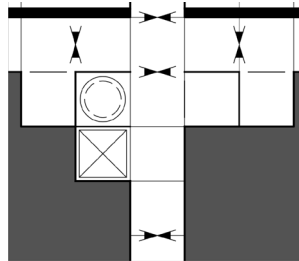
As the required space for all internal components is known, then it is a simple task to map out exactly where everything is to be located.

Arrangement of the internal components of a ship are based on the decisions made by you, the designer, but it is advised to follow a few simple practical design considerations.

Design Considerations

Accessibility

It is tempting to place an access hatch (to a deck below or above, or to a turret) in the middle of an access passage because it is the best place for it. Consider however, how the crew gets around that deck hatch or the retractable ladder (if it is an overhead hatch) when traversing the passage during daily routine or when there is an alert situation. Consider widening the passage around the hatch to provide that free access or place the hatch just out of the passage. Sometimes though, placing a hatch in an access passage cannot be avoided, a design flaw or compromise then.



Access passages are commonly 1.5m in width. However, width can be reduced to 1m if the passage is intended for maintenance or crew only access with passage width adjacent to hatches widened to 1.5m if deemed necessary.

Access flats should be provided on each deck where hatches or interdeck lifts provide access. These should be sized sufficiently to provide enough room for easy movement. Think of an access flat as a road intersection.

Bulkheads

When designing a ship consider how the internal layout of different areas would require to be separated by bulkheads. Bulkheads with secured iris hatches provide a ship with greater internal security and internal pressure integrity when a section of the ship is compromised due to hull breach or similar. A bulkhead might separate passenger and crew areas for example, the cargo hold to the crew compartment or the engineering spaces to the rest of the ship.

Cargo Hold

For most designs decide if the cargo hold will be one or two decks high and size appropriately. Remember a deck is 3m (or 2 x 1.5m grid squares) high. Clearly indicate on the deck plan (deck, overhead or side) where cargo hatches are located.

Crew and Passenger Accommodation

Always group the crew accommodation together with easy access to common areas. For military or large commercial vessels where segregation between ships officers and ship crew is required then place administrative areas (offices, gymnasium, or the medical bay) between the two accommodation areas. Perhaps consider having them on different decks.

The same guideline should be applied to passengers. Keeping passengers away from the working part of the spacecraft should always be an important consideration on security and safety grounds alone.

Engineering Spaces

The sum of the allocation for the various drives provides for space for the Engineering control areas and any smaller allocations for stores and maintenance. For larger areas required then an engineering workshop will provide that need. Map out the required size and configuration of how you want the engineering space to look like to suit the hull configuration of the ship and place the drives and the engineering control area(s) within that space.

Representing the drives can be done in any number of ways that suit the preference of the person creating the deck plans. These can be simple geometric shapes, complex gizmology or nothing at all.

Hangar Bay or Vehicle Garage

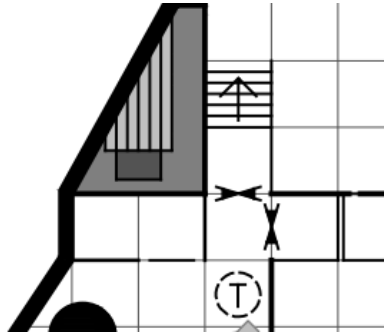
A hangar bay must be at least 1.5 decks in height (4.5m or 3 x 1.5m grid squares) to allow a small craft to be stored within while a vehicle garage is typically contained within a single deck. Clearly indicate on the deck plan (deck, overhead or side) where the access door(s) are located.

Hull Armor

Hull armor is included within the 20% allowable excess tonnage of a design if the hull armor allocation does not exceed 4 points. Representing hull armor on a deck plan can be easily achieved by appropriate line thickness or fill area. For example, each allocation of 4 points of hull armor can be represented by a line width on plan of 0.25m.

Stairs

Place these if there are internal height differences to the deck. Use an arrow symbol that points to the bottom of the stairs to indicate direction. Stairs are common for accesses into small craft hangar bays or where the cargo bay is two decks in height and the upper deck opens out to a higher-level catwalk. Sometimes a deck plan design for a yacht or space liner might include stairs rather than a hatch for access between decks. In this situation, ensure the stair well can be compartmented adequately to ensure no complications if there is a hull breach resulting in atmospheric pressure loss.

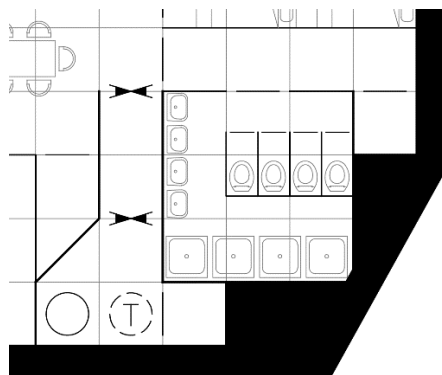


Storage space

Every portion of the deck area of a spacecraft is valuable space to be used, so allocating one deck plan square (0.5dT) to be used for installation of an equipment locker is good design practice. This can be placed at the terminal end of an access passage to staterooms for example.

Consider adding a 0.5dT EVA equipment storage locker adjacent to a deck airlock as that location is the most logical place for such the storage of such equipment to be located. Small storage spaces placed in logical locations on a deck are not considered part of the overall tonnage of the spacecraft.

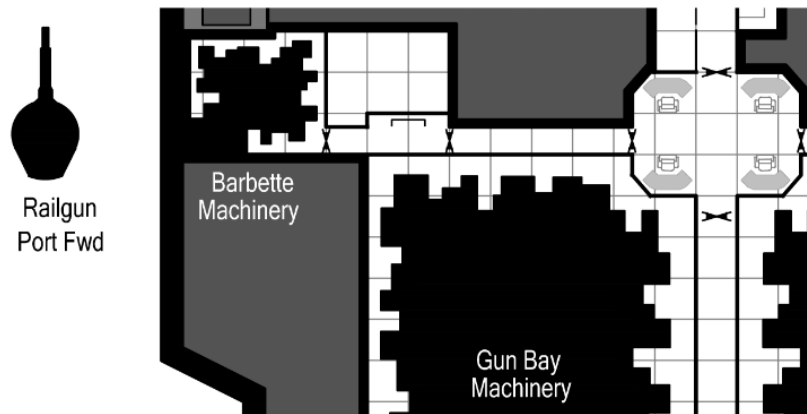
A small 0.25dT - 0.5dT weapons and equipment locker within the bridge is another consideration. The locker could contain EVA equipment, some emergency supplies, tools, and several small arms.



Weapon Barbettes and Bays

The space for a weapon barbette includes the barbette machinery, turret, space for fire control and if the bay requires ordnance, a small internal magazine. Like a turret, a barbette will require a magazine to be installed adjacent to provide for additional ordnance reloads. Access via a maintenance or full-size hatch should be shown on the deck plan.

Aside from drives and power plants, a weapon bay is one of the largest components added to a warship design. The allocation space for a weapon bay includes the bay machinery, turret, space for fire control and if the bay requires ordnance, a magazine. Like a turret and barbette, a bay will require a magazine to be installed adjacent to provide for additional ordnance reloads. The bay will require that a maintenance hatch or full-sized hatch access be shown on the deck plan.



Internal Details (Deck plan symbols)

Long standardized, deck plan symbols and line types on spacecraft deck plans are simple and easy to recognize, indicating what the fittings shown on deck plans are to be. All deck plans must be provided with a deck plan symbols legend as per international guidelines, all of which are continued to be in use by spacecraft construction companies throughout colonized space in both Earth and Clement Sectors.

Deck Plan Symbols

	Manual Hatch (overhead)
	Manual Hatch (deck)
	Iris Hatch (overhead)
	Iris Hatch (deck)
	Turret Access (overhead)
	Turret Access (deck)
	Iris Hatch
	Manual Hatch
	Interdeck Lift
	Sliding Door
	Interior Wall
	Bulkhead
	Maintenance Hatch
	Transparisteel Viewport

Manual Hatches

An older technology, manual hatches have been used to provide a pressure tight (watertight when used by sea vessels) seal between compartments for centuries.

Depending on the hatch's degree of sophistication a manual hatch is opened by a simple hand wheel or by an electronic control panel, which moves extended bars that lock the hatch into place.

The control panel will also indicate the atmospheric pressure status on the other side of the hatch or indicate if the hatch has been locked by the ship's computer. With either system, the ship's computer can detect if the hatch is opened or closed. Manual hatches can only be installed into a bulkhead or ship's hull.

Turret Accesses

Though turrets are controlled from the bridge or fire control stations, most turrets still have an interior iris hatch access to allow for firing under local control or for maintenance/repair. These accesses are located in the deck or overhead. Overhead turret accesses will have a fixed or retractable ladder to allow egress into the turret.

Iris Hatches

At higher technological levels iris hatches replace the standard manual hatch. Resembling a camera lens iris, an iris hatch is a pressure tight hatch that opens by retracting panels into the surrounding frame to allow egress. The hatch then closes again once egress has been completed.

Iris hatches can be programmed by the ship's computer to automatically open on approach or only be manually operated by a door control adjacent to the hatch. The control panel will also indicate the atmospheric pressure status on the other side of the hatch or indicate if the hatch has been locked by the ship's computer. Iris hatches can only be installed into a bulkhead or ship's hull.

An iris hatch will automatically close and lock if a pressure difference is sensed between the two sides of the bulkhead and will not close if it senses an obstruction. Because of this iris hatches are very difficult to force open when fully closed, requiring a Formidable task check. If the hatch is locked, apply an additional DM-3.

Interdeck Lifts

Common on many larger spacecraft, interdeck lifts provide access to crew, passengers, and goods. A pressure tight lift-pod located within a lift shaft extends between decks, with each deck separately protected by pressure doors to maintain integrity between each deck. Access to the interior of the lift-pod is via standard sliding doors that open to an access flat on each deck. A typical lift pod can carry up to ten people.

Sliding Doors

Sliding doors provide access through interior walls. These slide into recesses built into the walls and open when the door controls set into the wall adjacent to the door on either side of the wall are operated. The door access panel will indicate if the door is locked. Sliding doors are not pressure tight have the same strength characteristics as the interior wall it is part of.

Interior Walls

These are permanent non load bearing and non-pressure tight partitions that further divide the interior of the ship into smaller spaces. Interior walls are more fragile than bulkheads and can be breached by anti-personnel explosive or high energy weapons that cause 100 points of damage. Projectile weapons will take significantly longer to breach an interior wall, requiring 1000 points to achieve the same result as heavier weapons.

Bulkheads

A major structural component of a spacecraft, bulkheads divide the ship in pressure-tight compartments for the purposes of damage control, environmental control, and security. Significantly stronger than an interior wall a bulkhead can only be breached by anti-personnel explosive or high energy weapons that cause a total of 1000 points of damage. Projectile weapons are ineffective.

Maintenance Hatches

Located to provide access for maintenance purposes throughout a spacecraft, maintenance hatches are flush mounted panels that when interacted with open to provide access to the spaces within, a barquette's machinery space or ship's sensors for example. Maintenance hatches can be remotely opened by the ship's computer or by ship's officers and senior crewmembers.

Transparisteel Viewports

Transparisteel viewports are commonly used to provide outside views for passenger lounges and common areas on commercial passenger spacecraft. They are also used for bridge and small craft viewports. For military spacecraft however, transparisteel viewports represent a significant weakness in an armored hull and they will not be installed.



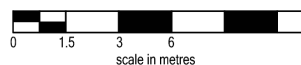
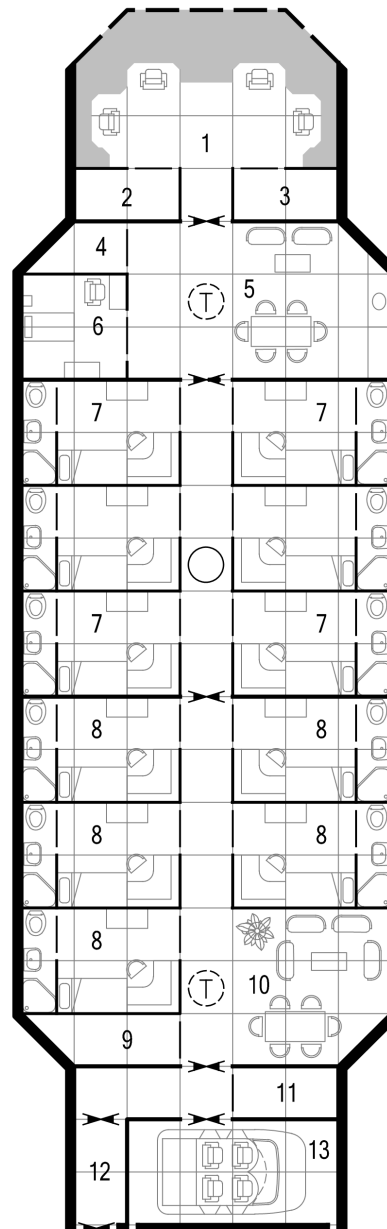
Billings Class Free Trader

Deck Plan Symbols

-  Manual Hatch (overhead)
-  Manual Hatch (deck)
-  Iris Hatch (overhead)
-  Iris Hatch (deck)
-  Turret Access (overhead)
-  Turret Access (deck)
-  Iris Hatch
-  Manual Hatch
-  Workstation
-  Sliding Door
-  Interior Wall
-  Bulkhead
-  Maintenance Hatch

Deck 1 - Upper Deck

1. Bridge
2. Computer Access
3. Ships Locker
4. Pantry
5. Crew Common Area
6. Medical Bay
7. Crew Quarters
8. Passenger Staterooms
9. Passenger Galley and Pantry
10. Passenger Lounge
11. Equipment Store
12. Airlock
13. Grav Utility Vehicle Bay



Billings Class Free Trader

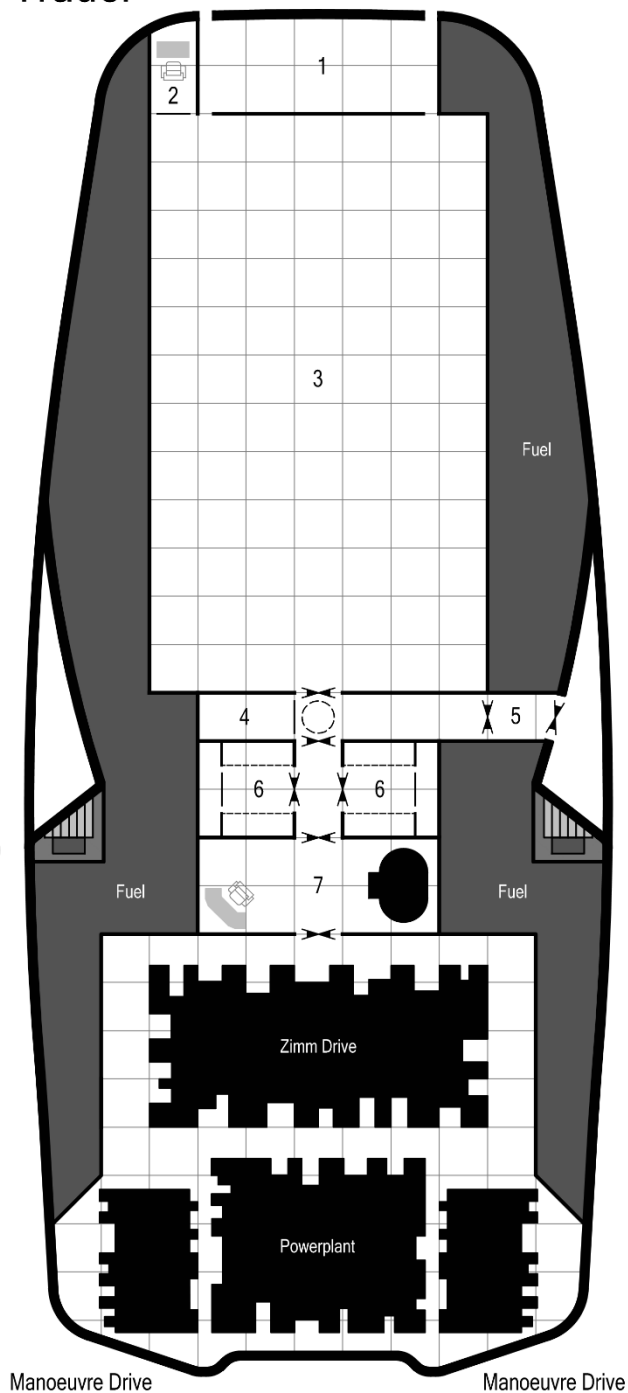
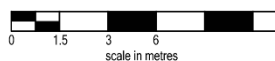
Deck Plan Symbols

- ⊙ Manual Hatch (overhead)
- ⊙ Manual Hatch (deck)
- Iris Hatch (overhead)
- Iris Hatch (deck)
- ⊙ Turret Access (overhead)
- ⊙ Turret Access (deck)
- ✕ Iris Hatch
- ✕ Manual Hatch
- Workstation
- Sliding Door
- Interior Wall
- Bulkhead
- Maintenance Hatch

Deck 2 - Lower Deck

- 1. Cargo Bay Airlock
- 2. Cargo Office
- 3. Cargo Bay
- 4. Engineering Stores
- 5. Airlock
- 6. Low Berths
- 7. Engineering

Fuel Scoop
(Both Sides)



DEFEND THE FEDERATION



The image features a woman with blonde hair in a dark flight suit, saluting with her right hand. Behind her, three Federation Navy ships are flying in a V-formation against a starry space background. A large, stylized 'H' logo is visible behind the ships. In the bottom left corner, there is a composite image of the German and British flags with a central crest featuring a crown and the letters 'HUB'.

HUB FEDERATION NAVY CAN YOU HANDLE IT?

FIND YOUR NEAREST RECRUITMENT STATION AND JOIN UP

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